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EFFECTS OF SIMULATED ACIDIC PRECIPITATION ON SASKATCHEWAN CROP AND FOREST SPECIES - RESULTS OF THE 1985/86 EXPERIMENTS

by

Z.M. Abouguendia
L.A. Baschak
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SRC Technical Report No. 191

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EXECUTIVE SUMMARY

The response of six Saskatchewan forest and crop species to simulated acid rain was studied under controlled growth room conditions. Jack pine, white spruce, aspen, alfalfa, wheat and canola were subjected to weekly applications of simulated rain with pH 5.6 (control), 4.6, 3.6 and 2.6 for up to 22 weeks. The main findings are summarized below:

Plant Effects

Under controlled growth room conditions, simulated acid rain (SAR) with pH of 3.6 or higher had minimal effects on the crop and forest species studied. The significant effects on plants were largely restricted to an unrealistically low pH level of 2.6, and these effects were either inhibitory or stimulatory to plant growth. Since plants sensitive to acid rain are affected at a pH of 4.0 or higher, none of the species investigated in this study can be classified as sensitive.

The two annual field crops tested, wheat and canola, were rather insensitive to SAR applied throughout their growing period. An increase in total aboveground biomass was noted for the two species at the pH 2.6 treatment, apparently due to the increase in the level of available nitrogen and sulphur in the soil (see soil effects below). However, no effects on the economic yield (wheat grain and canola seed) or root biomass were found with any of the treatments. No visible foliar injury was observed on wheat or canola.

Alfalfa appeared to be more sensitive to SAR than wheat and canola. Although no significant detrimental effects were noted on alfalfa at pH 3.6 or higher, chlorophyll a concentration was lowered and height of regrowth (towards the end of the experiment) was reduced at pH 2.6.

Foliar damage was observed at the same pH level. However, aboveground biomass and root biomass were not affected by any of the SAR treatments. The detrimental effects of acid rain appeared to have been masked by the temporary fertilization effect of the rain simulant components as indicated below.

Although visible foliar damage was observed on white spruce and aspen at pH 2.6, no significant detrimental effects were found on chlorophyll concentration, aboveground biomass, or root biomass.

Nutrient levels in the foliage were generally unaffected by rain acidity, with the exception of nitrogen (N) and sulphur (S). The levels of N and S were highly elevated at the more acidic treatments, particularly pH 2.6, reflecting the N and S input from the SAR. The apparent lack of decrease in the level of cation basis in the leaves may be due to the ability of the plants to increase their uptake from the soil to compensate for any leaching losses.

Soil Effects

SAR with pH lower than 4.6 resulted in a decrease in the pH of the forest soil tested by 0.1 to 0.5 units. Although this initial drop in soil pH may not be considered significant, continued increase in soil acidity, in the long term will be detrimental to plant growth.

While the water soluble cations in the soil increased with rain acidity, exchangeable Ca decreased significantly at pH 2.6, indicating depletion of base cations is taking place. This will lead to reduced soil fertility.

The levels of SO_4 and NO_3 increased substantially with the acidic treatments, particularly pH 2.6. This may have provided nutritional

effects which would mask short-term detrimental effects.

It is recommended that:

(1) testing of the response of the forest species and alfalfa to simulated acid rain be carried out under field conditions;

(2) data be collected on the buffering capacity of the northern Saskatchewan soils and on their response to simulated acid rain in order to evaluate the potential impacts of acid rain on terrestrial plants as well as on the aquatic ecosystems; and

(3) a program for field monitoring of the northern forest ecosystems be developed and implemented.

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The assistance provided by Mr. G. Padbury of the Saskatchewan Institute of Pedology in interpreting soils data is appreciated.

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1 INTRODUCTION

Acidification of precipitation as a result of emissions from fossil fuel combustion has been reported in many areas of the world, including eastern Canada. Damage to vegetation and reduction in forest productivity in those areas have been attributed to the acidic precipitation.

Although, at present, no significant precipitation acidification problems have been identified in Saskatchewan, the issue is of growing concern in view of future developments in the tar sand region of Alberta, the heavy oil areas of Saskatchewan and Alberta and the coal producing regions of southern Saskatchewan.

Reported potential effects of acidic precipitation on plants include reduction in photosynthesis and growth rates, premature senescence of leaves, chlorosis and necrosis of tissues, acceleration of nutrient leaching and increased susceptibility to other environmental stresses such as drought and disease. In addition, indirect detrimental effects could result from changes in soil chemistry.

Although several reports on the sensitivity of vascular plants to acidic precipitation appeared in the literature in recent years, virtually none of these studies dealt with western Canadian or Saskatchewan vegetation or crops.

This study is a part of a three-year research program to evaluate the potential effects of acidic precipitation on Saskatchewan forest plants and crops. The program which was initiated in 1984 is being funded cooperatively by the Saskatchewan Research Council, Saskatchewan Department of the Environment, and the Saskatchewan Power Corporation. The results of the 1984/85 investigations appeared in a detailed technical report (Abouguendia and Baschak 1985) and were summarized in the form of a scientific journal article (Abouguendia and Baschak 1986).

2 OBJECTIVES OF THE STUDY

The objectives of this study are:

(1) to assess the relative sensitivity of aspen (Populus tremuloides Michx.), white spruce (Picea glauca (Moench) Voss.), wheat (Triticum aestivum L.), alfalfa (Medicago sativa L.), and canola (Brassica napus L.) to acidic precipitation,

(2) to determine the threshold for direct injury of species studied, and

(3) to evaluate changes in soil chemical and physical characteristics resulting from the acidic precipitation to aid in the interpretation of possible indirect effects on plants.

3 METHODS

3.1 Plant Material

Aspen used was propagated from roots according to a procedure developed by Schier (1978) of the U.S. Forest Service. Final potting of aspen was carried out between October 26 and October 28, 1985.

Two year old, bare-root white spruce seedlings, obtained from the Prince Albert Forestry Nursery, were potted on October 15, 1985.

Neepawa wheat, Rambler alfalfa (treated with Thiram for verticillium wilt), and Regent canola (treated with Vitavax) were seeded on October 22, 1985.

3.2 Soil Material

Forest soil from the Prince Albert area was used for potting white spruce. Soil material used for the other species were obtained from the Saskatoon area. Characteristics of the soils used are given in Table 3.1.

Potting medium consisted of soil, peat moss and vermiculate at a ratio of 2:1:1, respectively.

3.3 Simulated Rain

Simulated rain solutions were prepared using the same procedures outlined in Abouguendia and Baschak (1985). The following treatments were included:

- pH 5.6, 2.5 eq L^{-1} H^+ (control)
- pH 4.6, 25 eq L^{-1} H^+ ("acidic")
- pH 3.6, 250 eq L^{-1} H^+ ("acidic")
- pH 2.6, 2500 eq L^{-1} H^+ ("acidic")

Table 3.1 Characteristics of the Soils Used in the Experiments.

Parameter	Forest Soil	Agricultural Soil
Texture	sandy loam	sandy loam
NO_3-N (ppm)	275	33
P (ppm)	22	16
K (ppm)	105	425
E. Conductivity (mS cm^{-1})	3.9	1.9
pH	4.6	6.4
Saturation (%)	54	50

In all treatments, deionized water produced by a Culligan Mixed Bed Deionizing System was used. Standard line, low flow, full cone nozzles (Series WL, 303 stainless steel, Beet Fog Ltd.) were mounted in a specially designed simulated acid rain application chambers (Abouguendia and Baschak 1985) (Figure 3.1).

Completely randomized experimental design with 20 replicates was used. Treatments started on November 19, 1985, for the forest species and wheat. First treatment for alfalfa and canola was carried out on November 26, 1985. Treatments then continued at approximately weekly intervals. Annual crops were treated till maturity. Aspen treatment was curtailed after both control and treated plants showed symptoms of nutrient deficiency. White spruce and alfalfa were treated till the end of the experiment. Relevant application information is summarized in Tables 3.2 to 3.4.

3.4 Growth Room Conditions

Initially, day temperature was maintained between 21 and 23°C. This was increased gradually to 25-27°C by the time of crop maturity. Night temperature was 16-17°C. Initial photoperiod was 12 hours. This was gradually increased to 14 hours starting January 20, 1986, at a rate of 15 minutes per day.

Pots were watered when needed between simulated rain events using city tap water.

3.5 Plant Measurements and Sampling (Table 3.5)

White spruce: Length of new apical growth was measured on February 27 and May 14, 1986. Needles were collected at the end of the experi-

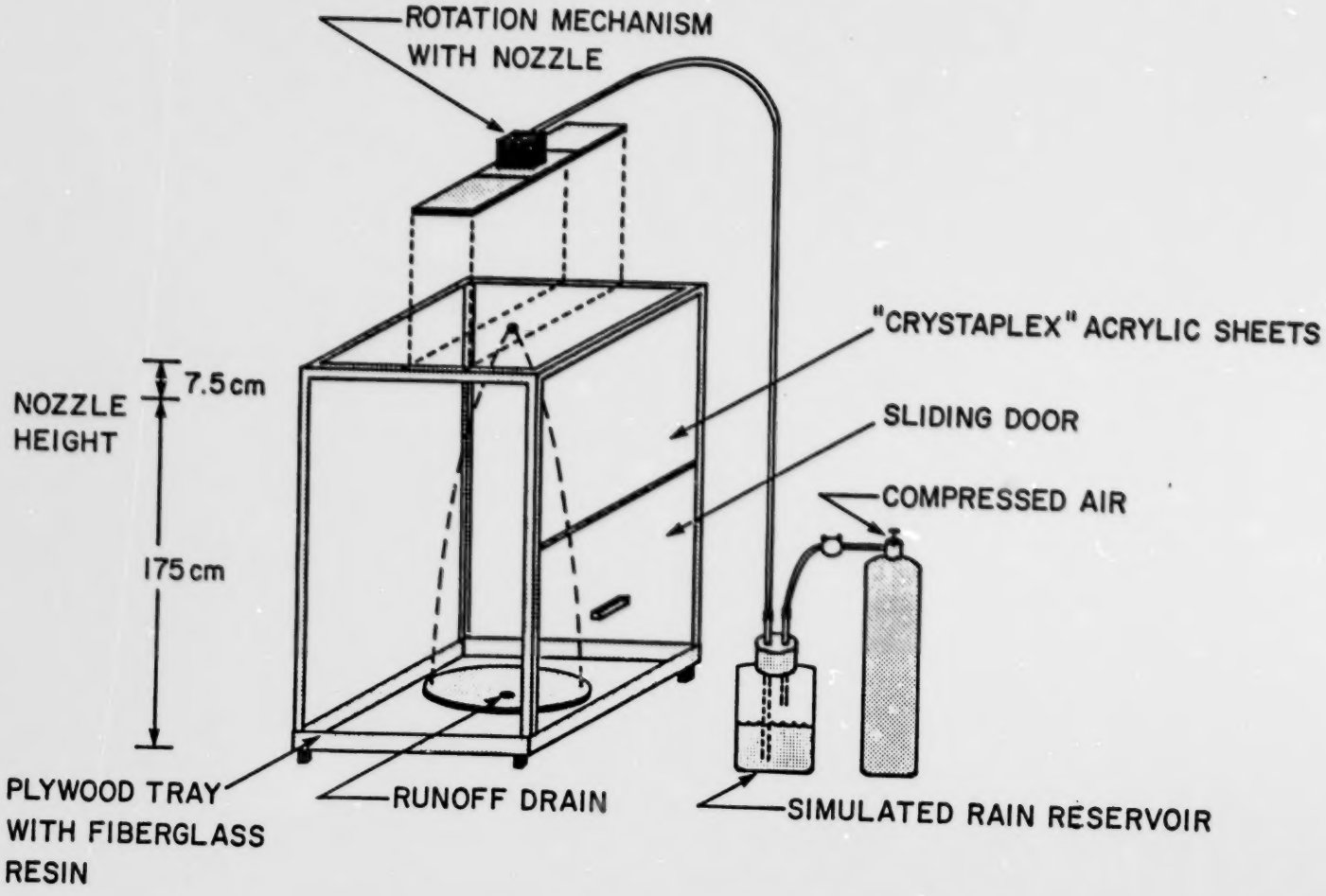

Figure 3.1 Detail of Treatment Chamber and Simulated Rain Dispensing System.

Table 3.2 Chemical Composition ($mg\ L^{-1}$) of the Rain Simulant (pH 5.6).

Major Ions	Concentration
Na^+	0.3
K^+	0.25
Mg^{++}	0.16
Ca^{++}	0.18
NH_4^+	0.27
Cl^-	0.35
NO_3^-	0.72
SO_4^{--}	1.7

Table 3.3 Final Concentration ($mg\ L^{-1}$) of SO_4 and NO_3 in the Simulated Acid Rain Treatments.

Treatment (pH)	SO_4	NO_3
5.6	1.7	0.72
4.6	2.6	1.12
3.6	10.8	5.12
2.6	90.2	44.02

Table 3.4 Number and Total Amount of Simulated Acid Rain (SAR) Applications Received by the Various Plant Species.

Species	Number of Applications*	Total Amount of SAR (mm)
White spruce	22	171
Aspen	12	102
Alfalfa	21	171
Wheat	12	102
Canola	10	85

*30 minute events, with only few exceptions.

Table 3.5 Summary of Plant Parameters Studied.

Species	Nutrients	Chlorophyll	Aboveground Biomass	Belowground Biomass	Foliar Injury	Height	Leaf Dimensions
White spruce	X	X	X	X	X	X	
Aspen	X	X	X		X		
Alfalfa	X	X	X	X	X	X	
Wheat			X	X	X	X	X
Canola			X	X	X	X	X

ment (May 14, 1986) for chlorophyll and nutrient analysis. At the same time, plant material was collected for biomass determination. The material was oven dried at 60°C for 48 hours before weighing to the nearest 0.01 g.

Aspen: Observations on chlorosis and necrosis were made at the same dates. Plant material was collected on February 18, 1986 for chlorophyll, nutrient analysis, and biomass determination.

Alfalfa: Visible damage observations were made at two dates (December 19, 1985 and January 20, 1986). Height of alfalfa plants was measured on four occasions: January 21, March 3, April 14 and May 1. Plant material was collected for chlorophyll analysis on February 17. Biomass determination was made on January 21, February 17, March 24, May 1, and May 12. Material from the March 24 clipping was used for foliage nutrient analysis.

Wheat: Leaf measurements were made on February 5, 1986. Wheat was harvested on February 17 for biomass and grain yield determinations.

Canola: Height and leaf measurements were carried out on February 5. Yield was determined at the end of the experiment.

3.6 Root Extraction

Belowground biomass was extracted by soaking the soil material from the experimental pots in water and manually agitating the root mass until the soil is washed off the roots. Following this procedure, the material was transferred to No. 12 sieve (1.68 mm opening) for further washing and for removal of peat moss and other foreign material. A minimal loss of fine roots was observed. The belowground biomass was then oven dried for 48 hours at 60°C.

No root extraction was made for aspen. The plants have been retained for further experimentation.

3.7 Soils Investigations

The soil material of the type used for potting white spruce seedlings (Table 3.1) was subjected to an amount of simulated acid rain solution equivalent to the May-September precipitation (Table 3.6) to evaluate possible changes in soil chemistry. The columns, weighing 350 g, were placed in polystyrene containers measuring 8.2 mm in diameter and 9 cm in height. The bottom of this container was equipped with a nylon membrane with 0.45 m pore size. The percolate receiving container is also made of polystyrene.

The same pH treatments used in the above experiments were applied to the soil columns. Six replicates were used in a completely randomized design. Alfalfa was seeded in the soil columns to introduce normal plant/soil interactions.

Leachates were collected following each application. Due to the insufficient material collected on individual dates, the leachates were combined in three composite samples for chemical analysis as indicated in Table 3.6. The parameters evaluated included soluble ions, pH, electrical conductivity, available nutrients and exchangeable cations.

3.8 Chemical Analysis

Plant nutrient analysis and chlorophyll determination were carried out by the Analytical Laboratories of the Saskatchewan Research Council as outlined in Table 3.7.

Table 3.6 Amount of Rain Simulant Applied to the Soils Columns and the Leachate Compositing Arrangement.

Sample No.*	Date	Volume (mL)
	May 21 (Immediately following seeding)	100
	May 26	50
	May 28	200
1	June 6	150
	June 12	200
2	June 16	150
	June 21	200
3	June 27	200
	July 2	200
	Total	1450

*Samples represent composited leachates from the dates indicated.

Table 3.7 Procedures Used in Foliar.

Parameter	Procedure
Total N	Kjeldahl
Total P	Colorimetric
K	Flame photometry
Total S	Bromine/perchloric gravimetric
Ca	Nitric/perchloric atomic absorption
Mg	Nitric/perchloric atomic absorption
Chlorophyll	Knudson (1977)

Soil and percolate analyses were conducted by the Saskatchewan Soil Testing Laboratories according to standard procedures.

3.9 Data Analysis

All data collected were subjected to analysis of variance. This was followed by Duncan's Multiple Range Test, where appropriate. The SYSTAT statistical routines (Wilkinson 1985) were used in the analysis.

4 RESULTS AND DISCUSSIONS

Only a summary of the data obtained in this study will be included in this section. All detailed data and statistial anlaysis can be found in the Appendices, where they are arranged in the same order as the following subsections.

4.1 Growth and Yield

Height of alfalfa plants was measured on four occasions during the experimental period (Table 4.1). With the exception of the first date, all height measurements represent regrowth after harvest. It appears from the data that the pH 4.6 treatment significantly stimulated the growth of alfalfa on the first date. On the second date, no significant differences between treatments were noted. The pH 2.6 treatment depressed height significantly on the third and fourth dates.

The aboveground biomass of alfalfa was not affected by any of the acid rain treatments (Table 4.2). It appears that the detrimental effects of high acidity have been masked by the fertilization effect resulting mainly from nitrogen and sulphur in the acid rain. These results agree with the findings of Evans et al (1982). Evans found no reduction in the biomass of alfalfa after 57 simulated rains of pH 2.7 over 105 days. Rebbeck and Brennan (1984) reported similar results using pH of 3.0. Cohen et al (1981) indicated increased yield at pH 4.0 and 3.5, but no effects at pH 3.0.

For canola, weight of foliage appears to have been stimulated by the most acidic treatment (Table 4.3). This was associated with increase in leaf width and length (Table 4.4). However, seed yield was not affected.

Table 4.1 Summary of the Alfalfa Plant Height (cm) Data. (Values are means of 20 samples followed, in brackets, by standard deviation.)

Treatment (pH)	Measurement Dates [a]			
	January 21	March 3	April 14	May 1
5.6	21.7 (3.8)	12.4 (3.8)	16.0 (4.3)	35.2 (5.9)
4.6	25.6 (5.8)*	12.3 (2.9)	15.3 (4.7)	31.7 (8.0)
3.6	24.6 (4.5)	12.5 (3.66)	14.5 (5.0)	31.1 (7.4)
2.6	22.1 (4.7)	10.1 (2.5)	10.1 (3.2)*	27.2 (5.8)*

[a] Plants were clipped on the following dates: January 21 (after height measurement), February 17, March 24, May 1 (after height measurement) and May 12.

*Significantly different from the control at the 0.05 level.

Table 4.2 Summary of the Aboveground Biomass (oven-dry basis) for Alfalfa. (Values are means (g) of 20 samples followed, in brackets, by standard deviation.)

Treatment (pH)	Last Cut	Total Biomass (All Cuts Combined)
5.6	0.561 (0.13)	2.31 (0.5)
4.6	0.567 (0.16)	2.29 (0.53)
3.6	0.681 (0.25)	2.49 (0.78)
2.6	0.590 (0.131)	2.06 (0.42)

Table 4.3 Summary of the Aboveground Biomass and Seed Weight (oven-dry basis) for Canola. (Values are means (g) of 20 samples followed, in brackets, by standard deviation.)

Treatment (pH)	Total Biomass	Seed Weight (with capsuls)
5.6	1.38 (0.23)	0.64 (0.19)
4.6	1.41 (0.21)	0.61 (0.19)
3.6	1.37 (0.24)	0.59 (0.23)
2.6	1.62 (0.4)*	0.72 (0.17)

*Significantly different from the control at the 0.05 level.

Table 4.4 Summary of the Leaf Measurements for Canola and Wheat. (Values are means (cm) of 20 samples.)

	Canola		Wheat
Treatment (pH)	Leaf Length	Leaf Width	Top Leaf Length
5.6	6.13 (0.78)	4.69 (0.7)	33.4 (4.1)
4.6	6.72 (0.98)*	5.19 (0.76)*	31.6 (4.5)
3.6	6.19 (0.9)	4.63 (0.71)	22.0 (3.9)
2.6	6.78 (0.82)*	5.31 (0.85)*	31.7 (6.2)

*Significantly different from the control at the 0.05 level.

Total aboveground biomass of wheat was stimulated by pH 2.6 (Table 4.5). However, this was not reflected in any increase in grain yield. Leaf length was not affected by the increasing rain acidity (Table 4.4).

No significant differences between treatments were found in the total aboveground biomass of aspen (Table 4.6).

Total aboveground biomass and weight of new growth of white spruce were not affected by increasing rain acidity (Table 4.7).

Length of new apical growth of white spruce was measured on two dates during the experiment. Rain acidity had no significant effects on rate of apical growth (Table 4.8).

4.2 Chlorophyll Concentration

Chlorophyll a and b were determined on foliage samples of the two forest species and alfalfa (Table 4.9). Rain acidity had no significant effect on chlorophyll b concentration of any of the species studied. Similar results were reported for white spruce and jack pine after seven applications of simulated rain ranging in pH from 5.6 to 2.6 (Abouguendia and Baschak 1985).

Chlorophyll a concentration in alfalfa leaflets was reduced significantly at pH 2.6. This, however, did not result in reduced yield as discussed in Section 4.1. The reduction in chlorophyll concentration may have been offset by the fertilization effect indicated above.

Chlorophyll a concentration in white spruce was greater at pH 3.6 than at pH 5.6 (Table 4.9). No differences in growth were noted however (Section 4.1). Aspen leaf chlorophyll a concentration was not affected by any of the acidic rain treatments (Table 4.9)

Table 4.5 Summary of the Aboveground Biomass (oven-dry basis) for Wheat. (Values are means (g) of 20 samples followed, in brackets, by standard deviation.)

Treatment (pH)	Total	Grain Weight
5.6	1.64 (0.19)	0.63 (0.16)
4.6	1.53 (0.17)	0.56 (0.12)
3.6	1.60 (0.15)	0.63 (0.14)
2.6	1.78 (0.25)*	0.63 (0.14)

*Significantly different from the control at the 0.05 level.

Table 4.6 Summary of the Aboveground Biomass (oven-dry basis) for Aspen. (Values are means of 20 samples followed, in brackets, by standard deviation.)

Treatment (pH)	Weight
5.6	3.32 (0.83)
4.6	2.98 (1.19)
3.6	3.18 (0.88)
2.6	3.34 (0.6)

Table 4.7 Summary of the Aboveground Biomass (oven-dry basis) for White Spruce. (Values are means (g) of 20 samples followed, in brackets, by standard deviation.)

Treatment (pH)	Total Biomass	New Growth
5.6	1.357 (0.54)	0.561 (0.169)
4.6	1.479 (0.753)	0.588 (0.165)
3.6	1.197 (0.395)	0.489 (0.143)
2.6	1.257 (0.453)	0.513 (0.154)

Table 4.8 Increase in Length (cm) of New Apical Growth of White Spruce Plants. (Values are means (g) of 20 samples followed, in brackets, by standard deviation.)

Treatment (pH)	February 27	May 14
5.6	1.35 (0.87)	1.34 (0.83)
4.6	1.55 (1.02)	1.49 (1.01)
3.6	1.52 (0.78)	1.49 (0.79)
2.6	1.46 (0.73)	1.42 (0.79)

Table 4.9 Summary of the Chlorophyll Data. (Values are means (ug/mg) of 20 observations and are followed by standard deviation.)

Treatment (pH)	Alfalfa		Aspen		White Spruce	
	Chlorophyll a	Chlorophyll b	Chlorophyll a	Chlorophyll b	Chlorophyll a	Chlorophyll b
5.6	3.24 (1.39)	1.02 (0.59)	2.18 (0.91)	0.82 (0.42)	2.56 (1.09)	1.10 (1.41)
4.6	3.53 (1.99)	1.16 (0.71)	2.62 (0.89)	0.94 (0.50)	2.89 (1.0)	0.58 (0.34)
3.6	2.68 (1.97)	0.64 (0.8)	2.80 (1.5)	0.84 (0.90)	3.46 (1.21)*	1.28 (0.94)
2.6	1.98 (1.11)*	0.79 (0.55)	2.64 (1.67)	0.87 (0.63)	2.31 (0.93)	1.55 (0.47)

*Significantly different from the control at the 0.05 level.

4.3 Foliar Injury

Wheat and canola showed no visible symptoms of injury from any of the acid rain treatments. For the other three species, the symptoms were largely restricted to the pH 2.6 treatment (Tables 4.10 to 4.12). Both chlorotic and necrotic spots were observed on the leaves of aspen (Figure 4.1). Although generally larger number of chlorotic and necrotic spots were noted for the acidic treatments, the only significant difference was indicated for pH 2.6 on December 11. The spots noted on the control plants (pH 5.6) appeared to have been caused by disease or insect damage.

Visible symptoms of injury in white spruce include chlorotic needle tip and necrotic needle tip. Some necrotic spots were also observed on other positions on the needle. The injury symptoms were particularly pronounced on the plants receiving the pH 2.6 treatment on the second and third observation dates (April 25, and May 14) (Table 4.11).

Whitish spots were observed on alfalfa leaflets (Figure 4.2, Table 4.12). The survey of damage was made on two occasions, December 19 and January 20. On both dates only pH 2.6 caused significant visible injury.

4.4 Foliage Nutrient Content

The concentration of the following nutrients was determined in white spruce needles, in aspen leaves and in alfalfa leaflets: calcium, potassium, magnesium, nitrogen, phosphorous, and sulphur (Tables 4.13 to 4.15). The results showed very few statistically significant differences. Sulphur and nitrogen concentrations increased in alfalfa and white spruce foliage receiving the more acidic treatments, reflecting

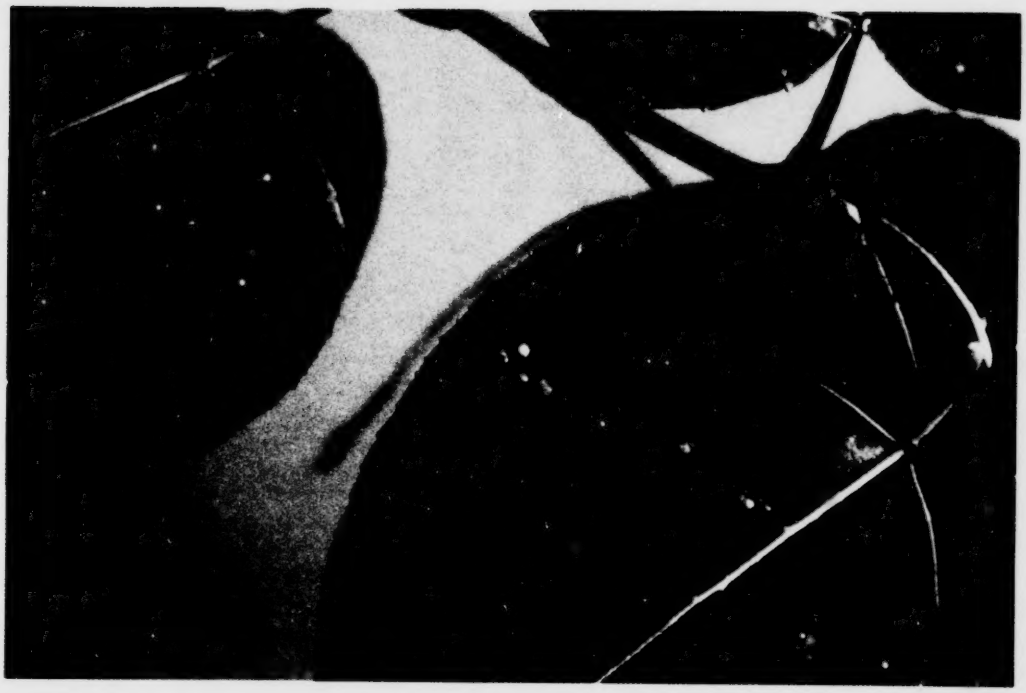

Figure 4.1. Aspen Leaves Showing Symptoms of Injury (Chlorosis and necrosis) Resulting from the pH 2.6 Treatment.

Figure 4.2. Alfalfa Leafle ts Exhibiting Symptoms of Injury Resulting from Simulated Acid Rain with pH 2.6.

Table 4.10 Total Number of Necrotic Spots Per Sampled Aspen Leaf. (Values are means of 20 samples and standard deviation (in brackets).)

Treatment (pH)	Number of Necrotic Spots on December 11	Total Number of Necrotic Spots
5.6	0.55 (0.95)	8 (19.9)
4.6	0.45 (0.99)	9 (15.2)
3.6	1.25 (3.89)	14 (20.5)
2.6	3.25 (3.25)*	20 (29.6)

*Significantly different from the control at the 0.05 level.

Table 4.11 Number of White Spruce Plants on Which Visible Symptoms of Injury were Observed.

Treatment (pH)	February 27	April 25	May 14
5.6	2	3	6
4.6	1	1	4
3.6	1	5*	8*
2.6	5	15*	18*

*Significantly different from the control at the 0.05 level.

Table 4.12 Number of Alfalfa Leaflets (per pot) with Visible Symptoms of Injury. (Values are means of 20 samples followed by standard deviations in brackets.)

Treatment (pH)	December 19, 1985	January 20, 1986
5.6	0.05 (0.224)	0.20 (0.523)
4.6	0.05 (0.224)	0
3.6	0.1 (0.31)	0.05 (0.224)
2.6	3.05 (2.59)*	17.95 (12.59)*

*Significantly different from the control at the 0.05 level.

Table 4.13 Summary of the Foliage Nutrient Data (%) for White Spruce. (Values are means of 10 samples and are followed in brackets by standard deviation.)

Treatment (pH)	P	Ca	K	Mg	N	S
5.6	0.46 (0.05)	1.52 (0.08)	0.53 (0.08)	0.28 (0.02)	2.94 (0.29)	0.17 (0.02)
4.6	0.35 (0.04)	1.36 (0.17)	0.49 (0.1)	0.25 (0.04)	2.79 (0.34)	0.16 (0.03)
3.6	0.39 (0.07)	1.52 (0.28)	0.5 (0.07)	0.27 (0.04)	2.89 (0.19)	0.22 (0.05)*
2.6	0.37 (0.09)	1.38 (0.25)	0.54 (0.05)	0.28 (0.034)	3.15 (0.19)	0.2 (0.03)*

*Significantly different from the control at the 0.05 level.

Table 4.14 Summary of the Foliage Nutrient Data (%) for Aspen. (Values are means of 10 samples and are followed in brackets by standard deviation.)

Treatment (pH)	P	Ca	K	Mg	N	S
5.6	0.2 (0.02)	2.1 (0.56)	1.29 (0.49)	0.46 (0.11)	1.74 (0.12)	0.424 (0.06)
4.6	0.18 (0.03)	2.26 (0.36)	1.49 (0.4)	0.5 (0.09)	1.64 (0.21)	0.44 (0.06)
3.6	0.19 (0.03)	1.94 (0.45)	1.37 (0.27)	0.38 (0.12)*	1.81 (0.18)	0.45 (0.07)
2.6	0.17 (0.02)	2.38 (0.15)	1.65 (0.29)	0.49 (0.04)	1.72 (0.19)	0.45 (0.04)*

*Significantly different from the control at the 0.05 level.

Table 4.15 Summary of the Foliage Nutrient Data (%) for Alfalfa. (Values are means of 10 samples and are followed in brackets by standard deviation.)

Treatment (pH)	P	Ca	K	Mg	N	S
5.6	0.26 (0.025)	1.29 (0.137)	3.24 (0.74)	0.33 (0.06)	3.26 (0.172)	0.291 (0.067)
4.6	0.26 (0.044)	1.42 (0.87)	3.31 (0.53)	0.358 (0.059)	3.51 (0.277)	0.339 (0.060)
3.6	0.275 (0.034)	1.39 (0.197)	3.17 (0.68)	0.337 (0.044)	3.42 (0.466)	0.365 (0.038)*
2.6	0.27 (0.036)	1.40 (0.183)	2.36 (0.59)*	0.357 (0.051)	4.03 (0.469)*	0.356 (0.053)*

*Significantly different from the control at the 0.05 level.

the high concentration of these two nutrients in the simulated rain used.

Nutrient leaching from foliage has been shown to increase with acidic precipitation (Hindawi et al 1980; Evans 1982). In this study, the concentration of nutrients in foliage was generally unaffected by the acid rain treatments. This could be due to the accelerated uptake of nutrients by plants from the available nutrient pool in the soil (Section 4.6) which would compensate for the losses caused by leaching. In the long-term, however, the level of available nutrients will be reduced, and nutrient content may be altered.

4.5 Belowground Biomass

Belowground biomass was determined at the end of the experiment for white spruce, alfalfa, wheat, and canola (Table 4.16). The belowground biomass of the species studied was not affected by rain acidity. The shoot:root weight ratio remained constant for the species evaluated, with the main exception of wheat where a large increase in that ratio was recorded at pH 2.6 (Table 4.17). While very few studies dealt with the effects of acidic precipitation on belowground biomass, our results compare generally well with Cohen et al (1981) who reported a reduction in root growth of wheat at pH 4.0 or lower. Lee et al (1981) indicated an increase in the shoot:root ratio of alfalfa. In this study, only a slight increase in the shoot:root ratio for alfalfa was noted with increasing rain acidity.

4.6 Soil and Leachate Chemistry

One of the major concerns over acidic precipitation is the poten-

Table 4.16 Summary of the Belowground Biomass Data. (Values are means (g) of six samples and are followed, in brackets, by standard deviation.)

Treatment (pH)	White Spruce	Alfalfa	Wheat	Canola
5.6	0.78 (0.33)	0.83 (0.26)	0.13 (0.04)	0.38 (0.07)
4.6	0.88 (0.19)	0.75 (2.14)	0.12 (0.03)	0.44 (0.06)
3.6	0.63 (0.21)	0.88 (0.29)	0.15 (0.1)	0.34 (0.08)
2.6	0.67 (0.18)	0.61 (0.14)	0.102 (0.03)	0.46 (0.07)

Table 4.17 Shoot:Root Ratio for Canola, Wheat, Alfalfa and White Spruce.

Treatment (pH)	Canola	Wheat	Alfalfa	White Spruce
5.6	5	13	0.7	1.7
4.6	5	13	0.8	1.7
3.6	6	11	0.8	1.9
2.6	5	18	1.0	1.9

tial for accelerated leaching of base cations from soils. In this study, the relatively coarse textured forest soil of the type used for potting white spruce seedlings (Table 3.1) was used to determine possible changes in some soil chemistry parameters with acidic precipitation. Simulated rain with pH of 5.6, 4.6, 3.6 or 2.6 was added to the soil as detailed in Section 3. Leachate chemistry data are summarized in Table 4.18, while the results of soil analysis at the end of the experiment are summarized in Tables 4.19 to 4.21.

No significant changes were noted in water soluble ions in the soil at the pH 4.6 treatment. At pH 3.6, only Ca^{++} increased significantly (23%) over the control. Electrical conductivity also increased.

At pH 2.6, more significant changes took place. The concentration of water soluble Ca^{++}, Mg^{++}, K^{+} and SO_4^{--} in the soil increased significantly. Of the cations, Ca^{++} showed the greatest increase (156%). A dramatic increase of more than 700% was noted for SO_4^{--}. Cl^{-} and Na^{+} showed no response to rain acidity. The lack of response of Na^{+} to the acidic treatment is somewhat surprising, since Na^{+} is attracted to the exchange sites less strongly than Ca^{++} and Mg^{++}.

Soil pH was not affected at the pH 4.6 treatment. This can be attributed to the buffering capacity of the soil. This buffering ability, however, was not sufficient to resist the change in soil pH at the two more acidic rain treatments. Soil pH dropped by 0.1 and 0.5 units with the pH treatments of 3.6 and 2.6, respectively. This is a result of the hydrogen ion replacing the base cations, particularly Ca, on the soil exchange sites.

From an econological point of view, the drop in soil pH observed here is considered small compared to possible natural intraseasonal and

Table 4.18 Summary of the Soil Leachate Chemistry Data. (Each value is a mean of six replicates followed, in brackets, by standard deviation.)

Treatment (pH)	Sample Collection Number	pH	Specific Conductivity mS cm^{-1}	Ions meq L^{-1}						Total Cations meq L^{-1}	Total Anions meq L^{-1}
				Ca^{++}	Mg^{++}	K^{+}	Na^{+}	Cl^{-}	SO_4^{--}		
5.6	1	6.37 (0.14)	0.19 (0.03)	1.5 (0.15)	0.6 (0.13)	0.3 (0.0)	0.3 (0.0)	0.3 (0.0)	0.45 (0.06)	2.35 (0.29)	0.75 (0.08)
	2	6.7 (0.28)	0.163 (0.02)	0.97 (0.14)	0.45 (0.06)	0.2 (0.0)	0.32 (0.04)	0.23 (0.05)	0.48 (0.04)	1.95 (0.21)	0.73 (0.08)
	3	6.5 (0.25)	0.17 (0.02)	1.07 (0.1)	0.47 (0.08)	0.18 (0.04)	0.37 (0.05)	0.15 (0.06)	0.58 (0.04)	2.08 (0.18)	0.78 (0.04)
	Mean	6.5	0.17	1.18	0.51	0.23	0.33	0.23	0.50	2.13	0.75
4.6	1	6.5 (0.11)	0.19 (0.03)	1.13 (0.31)	0.6 (0.25)	0.3 (0.0)	0.32 (0.04)	0.33 (0.08)	0.5 (0.06)	2.32 (0.62)	0.78 (0.13)
	2	6.6 (0.5)	0.19 (0.06)	1.18 (0.51)	0.57 (0.27)	0.22 (0.04)	0.33 (0.05)	0.28 (0.13)	0.62 (0.1)	2.32 (0.9)	0.92 (0.2)
	3	6.59 (0.76)	0.21 (0.08)	1.27 (0.68)	0.62 (0.35)	0.22 (0.04)	0.37 (0.05)	0.17 (0.05)	0.73 (0.29)	2.43 (1.1)	0.9 (0.26)
	Mean	6.6	0.20	1.19	0.60	0.25	0.34	0.26	0.62	2.36	0.87

Table 4.18 (Continued).

Treatment (pH)	Sample Collection Number	pH	Specific Conductivity mS cm^{-1}	Ions meq L^{-1} Ca^{++}	Mg^{++}	K^{+}	Na^{+}	Cl^{-}	SO_4^{--}	Total Cations meq L^{-1}	Total Anions meq L^{-1}
3.6	1	6.43 (0.4)	0.47 (0.61)	1.23 (0.21)	0.63 (0.14)	0.28 (0.04)	0.32 (0.04)	0.28 (0.04)	0.6 (0.09)	2.48 (0.34)	0.92 (0.08)
	2	7.0 (0.22)	0.22 (0.04)	1.32 (0.37)	0.68 (0.31)	0.23 (0.05)	0.32 (0.04)	0.27 (0.08)	0.77 (0.05)	2.55 (0.7)	1.03 (0.1)
	3	6.67 (0.77)	0.23 (0.05)	1.48 (0.66)	0.68 (0.31)	0.18 (0.04)	0.42 (0.04)	0.23 (0.19)	0.92 (0.1)	2.77 (1.0)	1.15 (0.19)
	Mean	6.7	0.31	1.34	0.66	0.23	0.35	0.26	0.76*	2.6	1.03*
2.6	1	6.27 (0.46)	0.46 (0.03)	2.63 (0.2)	1.47 (0.1)	0.37 (0.05)	0.33 (0.05)	0.25 (0.06)	2.22 (0.13)	4.8 (0.3)	2.47 (0.15)
	2	6.4 (0.19)	0.53 (0.05)	3.18 (0.31)	1.73 (0.1)	0.3 (0.0)	0.35 (0.08)	0.23 (0.05)	3.0 (0.21)	5.58 (0.42)	3.25 (0.27)
	3	6.19 (0.18)	0.6 (0.05)	3.87 (0.35)	2.05 (0.16)	0.2 (0.0)	0.43 (0.05)	0.17 (0.05)	3.82 (0.26)	6.55 (0.51)	3.98 (0.29)
	Mean	6.3	0.53*	3.23*	1.75*	0.29*	0.37	0.22	3.01*	5.6*	3.23*

*Significantly different from the control at the 0.05 level.

Table 4.19 Summary of the Soil Salinity Analysis. (Each value is a mean of six replicates followed, in brackets, by standard deviation.)

Treatment (pH)	pH	Water Soluble Ions (ug mL^{-1})						Conductivity (mS cm^{-1})
		Ca^{++}	Mg^{++}	K^{+}	Na^{+}	SO_4^{--}	Cl^{-}	
5.6	6.3 (0.05)	44.2 (4.5)	17.8 (1.7)	10.5 (0.8)	11.0 (3.0)	21.6 (10.6)	11.8 (8.0)	0.35 (0.060)
4.6	6.3 (0.05)	50.3 (2.3)	15.8 (1.3)	10.5 (0.5)	11.0 (0.3)	26.7 (2.3)	11.8 (1.2)	0.38 (0.04)
3.6	6.2* (0.04)	54.2* (5.3)	18.7 (2.3)	10.8 (0.8)	11.2 (1.6)	41.7) (10.8)	9.3 (1.4)	0.42* (0.04)
2.6	5.8* (0.06)	113.0* (9.9)	39.7* (3.9)	14.7* (1.03)	12.8 (0.8)	180.0* (52.2)	12.8 (1.2)	0.92* (0.04)

*Significantly different from the control at the 0.05 level.

Table 4.20 Summary of Soil Exchangeable Cations (ppm). (Each value is a mean of six replicates followed, in brackets, by standard deviation.)

Treatment (pH)	Ca	Mg	Na	K
5.6	2091 (105)	273 (15.5)	28.3 (4.1)	103.3 (7.5)
4.6	2091 (66)	273 (6.7)	30.2 (0.4)	103.3 (5.2)
3.6	2048 (81)	273 (13.1)	25.0 (5.5)	100.2 (0.4)
2.6	1963 (66)*	258 (9.8)	26.7 (8.2)	93.3 (8.2)

*Significantly different from the control at the 0.05 level.

Table 4.21 Summary of the Available Nutrient Data. (Each value is a mean of six replicates followed, in brackets, by standard deviation.)

Treatment (pH)	Nutrients (ppm)			
	NO_3-N	P	K	SO_4-S
5.6	4.2 (0.9)	5.0 (0.55)	99.2 (17.7)	4.9 (0.38)
4.6	3.8 (0.68)	5.3 (0.27)	91.7 (2.6)	5.6 (0.6)
3.6	4.2 (1.29)	5.3 (0.27)	89.2 (2.0)	7.9 (2.6)*
2.6	8.3 (2.4)*	5.5 (0.45)	85.8 (5.8)	12.2 (0.41)*

*Significantly different from the control at the 0.05 level.

interseasonal fluctuations in soil pH. However, continued increased acidity in the long term is a possibility. Soil acidity can affect plant growth directly or indirectly through altering the status of nutrient availability and the solubility of toxic elements.

Exchangeable cations (NH_4OAc extractable) showed no significant change in response to rain acidity, with the exception of Ca^{++}. Exchangeable Ca^{++} decreased significantly by the pH 2.6 treatment.

Available nutrients in the pH 4.6 and 3.6 treatments remained similar to the control. At pH 2.6, only nitrogen and sulphur increased significantly in response to their increased concentration in the simulated acid rain. This is reflected in elevated concentrations of these two nutrients in the foliage of some of the plants studied (Section 4.4).

The percolate analysis data indicated no accelerated leaching of cations with the pH 4.6 treatment. This is in agreement with the soil analysis data. Also, pH and conductivity remained at the same level as the control.

At pH 3.6, SO_4^{--} concentration in the leachates was significantly greater than that of the control, but pH showed no significant change.

As with the soils data, several changes in leachate chemistry were noted with the pH 2.6 treatment. Significant increase in all cations took place, with the exception of Na^+ which remained at the same level as the control. Cl^- showed no response to rain acidity. SO_4^{--} was elevated in the soil leachates. Leachate electrical conductivity increased largely due to the increase in SO_4^{--} and NO_3^-, but the pH remained unchanged.

The concentration of some ions (i.e. Ca^{++}, Na^+, and SO_4^{--}) in the leachates increased significantly with time, particularly at the pH 2.6

treatment. The concentration of Mg^{++} did not change with collection date. A decrease in K^{+} and Cl^{-} was noted with time.

From the above results it appears that significant changes in soil chemistry and leaching rates of base cations after nine applications of simulated acid rain were largely confined to the extreme pH treatment of 2.6. However, the data suggest possible long-term depletion of base cations, particularly Ca^{++}. A significant increase in these cations was found in the leachates, and this was accompanied by a reduced exchangeable Ca (H replaces Ca on the exchange sites). Also, K^{+} concentration in the leachates decreased significantly with time indicating depletion of available exchangeable K. Reduction in the level of such plant nutrients would mean reduced soil fertility and plant growth. However, further investigations are needed to determine the long-term effects of the less extreme pH levels, which are commonly found in areas presently affected by acidic deposition, i.e. eastern Canada.

4.7 General Discussion

The study showed that the effects of acidic precipitation on the crop and forest species tested are minimal. Significant effects were largely restricted to the unrealistically low pH of 2.6. The effects are either positive (e.g. growth stimulation as a result of increased available nitrogen, and possibly sulphur, levels) or negative (e.g. foliage injury, reduction in chlorophyll content). Sensitive plants are affected adversely at a pH of around 4.0 (see for example Keever 1982 and Evans et al 1982). It appears, therefore, that none of the species evaluated in this study can be considered sensitive to acidic precipitation.

The economic yield of annual field crops (e.g. wheat grain) was insensitive to acidic precipitation applied throughout their growing period. This suggests that for such crops only the long-term indirect effects (soil-mediated effects) would be the main concern. In the case of perennial forage crops and tree species, the plants were exposed to the acid rain treatment over a small portion of their life span. The cumulative effects, both direct and indirect, are still unknown.

The present investigations were carried out under controlled growth room conditions. Under these conditions, environmental stress factors, other than acidic precipitation, were virtually absent. Under field conditions, such factors as disease, insects, other airborne pollutants, rain intensity, temperature, and soil nutrient availability may interact to modify the response of plants to acid rain.

The nature of these interactions is extremely complex, is difficult to study, and is virtually unexplored. However, examples of the possible interactions are available in the literature. Shriner (1978) reported on the effects of simulated acid rain on parasite-host interactions; Shriner and Johnson (1981) reported on legume-rhizobium interactions in response to acidic rain; Like and Klein (1985) studied nitrification and nitrogen mineralization in the soil; Raynal et al (1982) indicated the importance of available nutrient conditions. Irvin et al (1981) found that rain with a chemistry that is varied from event to event had a different effect on plant growth than did a constant rain chemistry with the same mean pH.

However, Hofstra (1986) postulated that under "outdoor" conditions plants are more tolerant to acid rain than under controlled greenhouse conditions, but no supporting data were given. Similar suggestions were

made by Evans et al (1982).

As a result of the above limitations, therefore, direct extrapolation from controlled environment experiments to field conditions is difficult and should be made with caution. Varification of the growth room data under field conditions would be desirable. Field studies require substantial amount of time and labour, as well as sophisticated facilities.

In this study, the pH of the control treatment was 5.6, the theoretical pH of nonpolluted rain (i.e. the same as pure water in equilibrium with carbon dioxide). It should be noted, however, that the "background" precipitation pH in Saskatchewan may range from less than 4.5 to more than 7.0.

The soils experiment carried out in this study was designed to aid in the interpretation of the plant data collected, rather than to provide a systematic evaluation of the response of Saskatchewan soils to acidic precipitation. Intact soil columns with a more realistic depth representing a range of soils with varying cation exchange capacity, organic matter content, texture, and pH would be necessary for such evaluation. Furthermore, no data on the levels of toxic metals, such as aluminum, were collected in this study. Nevertheless, the experiment yielded data which indicate the potential importance of long-term effects on soils, particularly the loss of soil cations and the lowering of soil pH.

The soils of southern Saskatchewan appear to possess a relatively high acid buffering capacity (Abouguendia et al 1981; Shewchuk and Abouguendia 1985). No data are available on the soils of northern Saskatchewan. Shewchuk et al (1981) presented a tentative classification

of soil sensitivity to acidification for northern Saskatchewan based research findings acquired elsewhere and identified the need for testing the applicability of the principles and guidelines used in that classification directly under local conditions. Knowledge of the response of the soils of that region to simulated acidic rain would be needed to evaluate the potential impacts of acid rain on terrestrial plants as well as the aquatic ecosystems.

In southern Saskatchewan, the effect of acidic precipitation on soil pH may be intensified by agricultural practices. Nitrogen fertilization has been shown to be a major cause of soil acidification in Alberta (Hoyt et al 1981). A recent study in southern Saskatchewan (Campbell and Zetner 1984) indicated a reduction in soil pH of 0.5 unit over a 17-year period as a result of nitrogen/phosphorous fertilization in a well-buffered soil (C.E.C. 23.5 meq/100 g).

5 CONCLUSIONS

(1) Under controlled growth room conditions, simulated acid rain (SAR) with pH of 3.6 and higher had minimal effects on the crop and forest species studied.

(2) The significant effects on plants were largely restricted to an unrealistically low pH level of 2.6, and these effects were either inhibitory or stimulatory to plant growth. Since plants sensitive to acid rain are affected at a pH of 4.0 or higher, none of the species investigated in this study can be classified as sensitive.

(3) The two annual field crops tested, wheat and canola, were rather insensitive to SAR applied throughout their growing period. An increase in total aboveground biomass was noted for the two species at the pH 2.6 treatment , apparently due to the increase in the level of available nitrogen and sulphur in the soil (item #8). However, no effects on the economic yield (wheat grain and canola seed) or root biomass were found with any of the treatments. No visible foliar injury was observed on wheat or canola.

(4) Alfalfa appeared to be more sensitive to SAR than wheat and canola. Although no significant detrimental effects were noted on alfalfa at pH 3.6 or higher, chlorophyll a concentration was lowered and height of regrowth (towards the end of the experiment) was reduced at pH 2.6. Foliar damage was observed at the same pH level. However, aboveground biomass and root biomass were not affected by any of the SAR treatments. The detrimental effects of acid rain appeared to have been masked by the temporary fertilization effect of the rain simulant components (see item #8).

(5) Although visible foliar damage was observed on white spruce and aspen at pH 2.6, no significant detrimental effects were found on chlorophyll concentration, aboveground biomass, or root biomass.

(6) Nutrient levels in the foliage were generally unaffected by rain acidity, with the exception of nitrogen (N) and sulphur (S). The levels of N and S were highly elevated at the more acidic treatments, particularly pH 2.6, reflecting the N and S input from the SAR. The apparent lack of decrease in the level of cation basis in the leaves may be due to the ability of the plants to increase their uptake from the soil to compensate for any leaching losses.

(7) SAR with pH lower than 4.6 resulted in a decrease in the pH of the forest soil tested by 0.1 to 0.5 units. Although this initial drop in soil pH may not be considered significant, continued increase in soil acidity, in the long term, will be detrimental to plant growth.

(8) While the water soluble cations in the soil increased with rain acidity, exchangeable Ca decreased significantly at pH 2.6, indicating depletion of base cations is taking place. This will lead to reduced soil fertility.

(9) The levels of SO_4 and NO_3 increased substantially with the acidic treatments, particularly pH 2.6. This may have provided nutritional effects which would mask short-term detrimental effects.

(10) Data on the buffering capacity of the soils of northern Saskatchewan are lacking. Further studies are needed to evaluate the response of the northern Saskatchewan soils to acidic precipitation.

(11) Field testing is needed to verify the results of the controlled growth room study. Since the main concern appears to be cumulative long-term (both direct and soil mediated) effects, further studies

should focus on perennial species (e.g. alfalfa) and tree species, rather than annual field crops.

6 RECOMMENDATIONS

It is recommended that:

(1) testing of the response of the forest species and alfalfa to simulated acid rain be carried out under field conditions;

(2) data be collected on the buffering capacity of the northern Saskatchewan soils and on their response to simulated acid rain in order to evaluate the potential impacts of acid rain on terrestrial plants as well as on the aquatic ecosystems; and

(3) a program for field monitoring of the northern forest ecosystems be developed and implemented.

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APPENDICES

APPENDIX A

GROWTH AND ABOVEGROUND BIOMASS

Appendix A.1 Alfalfa Plant Height (cm) Data.

Measurement Dates	Replicate	Treatment (pH)			
		5.6	4.6	3.6	2.6
January 21	1	19.0	25.0	27.0	23.0
	2	23.0	30.0	27.0	28.0
	3	21.0	18.0	29.0	21.0
	4	23.0	33.0	26.0	21.0
	5	14.0	24.0	25.0	27.0
	6	25.0	24.0	30.0	16.0
	7	21.0	20.0	17.0	20.0
	8	26.0	20.0	24.0	19.0
	9	20.0	15.0	20.0	16.0
	10	16.0	31.0	19.0	21.0
	11	23.0	33.0	30.0	19.0
	12	24.0	19.0	32.0	21.0
	13	21.0	32.0	24.0	23.0
	14	30.0	27.0	20.0	29.0
	15	26.0	31.0	22.0	16.0
	16	17.0	19.0	32.0	33.0
	17	23.0	33.0	24.0	22.0
	18	22.0	23.0	20.0	26.0
	19	18.0	30.0	21.0	17.0
	20	21.0	24.0	23.0	24.0
March 3	1	14.7	13.2	15.2	9.4
	2	10.4	9.5	12.5	12.9
	3	8.8	10.7	14.6	8.1
	4	15.1	16.5	16.7	16.0
	5	11.5	7.6	13.1	6.3
	6	16.0	10.0	12.1	6.3
	7	13.6	6.6	6.3	9.0
	8	8.6	13.0	15.2	9.2
	9	8.6	12.8	12.4	7.6
	10	11.7	15.5	6.8	11.6
	11	14.3	11.5	11.0	14.1
	12	8.9	12.6	17.1	9.5
	13	14.3	15.2	16.4	11.2
	14	17.2	15.7	19.1	12.1
	15	6.4	11.4	9.6	9.3
	16	6.9	13.7	11.3	10.7
	17	10.0	17.2	10.8	9.6
	18	15.3	8.6	6.0	8.5
	19	20.5	11.8	9.5	12.2
	20	15.8	12.5	13.8	8.4

Appendix A.1 (Continued)

Measurement Dates	Replicate	Treatment (pH)			
		5.6	4.6	3.6	2.6
April 14	1	18.4	19.0	16.0	6.0
	2	17.5	9.8	19.4	12.3
	3	10.2	12.0	15.0	6.2
	4	15.1	19.1	14.5	14.2
	5	12.4	6.2	17.3	9.1
	6	18.5	17.8	12.4	5.6
	7	16.7	12.2	5.2	13.7
	8	9.3	14.2	19.1	11.6
	9	14.0	10.4	10.9	7.2
	10	23.7	17.3	6.3	9.4
	11	17.5	20.3	10.2	16.4
	12	14.3	19.4	20.3	10.4
	13	12.5	22.0	17.9	10.9
	14	19.3	14.2	22.7	13.3
	15	19.7	14.5	11.0	9.4
	16	7.0	13.0	15.1	13.2
	17	14.2	23.5	14.3	10.8
	18	20.5	6.8	6.0	5.4
	19	21.7	15.6	20.7	8.5
	20	17.1	11.8	15.4	7.4
May 1	1	45.9	31.0	29.3	18.5
	2	31.4	30.8	29.3	35.4
	3	29.2	21.9	32.2	21.2
	4	31.0	43.3	22.4	31.0
	5	26.0	27.1	32.2	34.0
	6	40.8	39.3	31.2	21.0
	7	32.0	33.2	16.6	25.5
	8	30.9	30.6	51.6	31.0
	9	32.3	19.5	21.0	22.6
	10	42.5	34.5	22.4	24.5
	11	39.4	49.0	29.6	29.4
	12	32.0	32.2	36.9	26.8
	13	37.0	38.8	32.5	33.6
	14	42.7	31.9	35.9	26.1
	15	42.7	26.1	30.5	29.2
	16	30.1	20.3	34.9	35.6
	17	33.6	39.5	35.5	34.4
	18	40.5	19.9	23.4	17.8
	19	36.8	36.3	38.9	20.7
	20	27.3	28.5	29.6	25.4

Appendix A.2 Leaf Measurements (cm) - Canola and Wheat.

Parameter	Replicate	Treatment (pH) 5.6	4.6	3.6	2.6
Canola					
Leaf Length	1	6.9	6.7	5.6	5.0
	2	7.0	6.9	5.6	7.2
	3	7.1	5.7	6.7	6.7
	4	6.4	5.5	5.5	6.5
	5	5.5	6.2	5.8	7.1
	6	6.5	6.0	6.1	5.5
	7	6.2	8.0	6.3	7.8
	8	5.3	6.8	5.7	5.7
	9	5.4	7.3	6.7	6.4
	10	4.4	8.6	4.8	6.0
	11	4.8	5.2	6.7	7.4
	12	6.7	6.7	7.1	7.9
	13	6.5	7.7	7.0	7.5
	14	6.2	7.2	6.1	6.3
	15	5.5	5.4	5.6	7.6
	16	6.6	6.5	5.0	7.4
	17	7.0	5.3	6.2	6.0
	18	6.5	7.7	5.2	7.4
	19	5.5	7.6	8.2	6.9
	20	6.5	7.4	7.9	7.4
Leaf Width	1	5.5	5.1	4.3	4.0
	2	5.0	5.4	4.5	5.4
	3	5.0	4.8	4.9	5.0
	4	5.1	4.2	4.4	5.4
	5	4.2	4.3	4.5	4.7
	6	4.4	5.3	4.9	4.4
	7	5.2	6.0	4.8	7.1
	8	3.7	4.8	3.7	4.2
	9	4.7	5.7	5.1	4.9
	10	3.2	6.4	3.3	4.4
	11	3.3	3.6	5.1	5.5
	12	5.0	5.1	5.5	5.5
	13	5.1	6.0	4.9	6.8
	14	5.4	5.8	4.9	5.1
	15	4.2	4.3	4.2	6.3
	16	4.4	5.4	3.5	6.1
	17	5.7	4.4	4.9	4.4
	18	5.4	5.4	3.7	5.5
	19	4.5	6.4	6.1	5.6
	20	4.8	5.3	5.4	5.8

Appendix A.2 (Continued)

Parameter	Replicate	Treatment (pH) 5.6	4.6	3.6	2.6
Wheat	1	25.3	24.1	30.3	33.2
Top Leaf Length	2	38.5	35.1	29.0	31.3
	3	30.2	32.1	33.7	14.5
	4	31.4	38.9	32.2	35.2
	5	39.9	30.7	32.0	40.8
	6	30.7	32.3	34.5	37.7
	7	37.6	28.0	23.3	32.5
	8	34.0	30.3	37.2	32.8
	9	38.8	32.3	34.3	30.6
	10	30.2	36.7	31.2	35.9
	11	32.2	29.9	31.0	34.7
	12	37.5	27.5	30.2	32.7
	13	34.8	27.2	37.2	32.3
	14	28.4	24.2	24.9	35.4
	15	29.9	31.8	35.1	19.0
	16	37.0	36.0	32.6	37.2
	17	35.5	38.5	33.2	27.1
	18	31.1	37.0	33.8	34.3
	19	31.6	28.4	38.0	30.0
	20			26.6	26.3

Appendix A.3 Increase in Length (cm) of New Apical Growth of White Spruce Plants.

Measurement Dates	Replicate	Treatment (pH)			
		5.6	4.6	3.6	2.6
February 27	1	0.9	1.5	1.5	1.0
	2	0.0	1.3	1.2	0.9
	3	1.8	1.0	1.9	2.0
	4	1.6	5.0	0.9	1.9
	5	1.2	2.3	2.1	0.5
	6	0.6	1.4	0.5	1.8
	7	0.5	2.1	1.5	0.9
	8	2.0	2.1	2.6	1.7
	9	1.3	1.8	1.0	1.0
	10	0.2	1.0	0.8	1.3
	11	1.8	2.2	2.6	2.6
	12	1.3	1.8	1.5	3.0
	13	1.1	0.5	1.4	0.3
	14	1.5	1.3	2.0	1.6
	15	0.0	1.3	--	1.5
	16	3.3	1.3	1.6	1.3
	17	2.0	1.8	3.2	2.5
	18	2.9	0.4	0.3	1.1
	19	1.3	0.0	1.8	1.9
	20	1.7	0.9	0.4	0.4
May 14	1	0.7	1.5	1.4	1.0
	2	0.0	1.6	1.1	0.6
	3	1.5	0.8	1.9	2.2
	4	1.5	4.9	0.9	2.1
	5	1.1	2.4	2.1	0.9
	6	0.7	1.3	0.4	2.4
	7	0.6	2.2	1.9	0.7
	8	2.0	1.8	2.6	1.5
	9	1.4	1.7	1.1	0.9
	10	0.4	1.0	0.8	1.2
	11	1.6	2.1	2.5	2.7
	12	1.7	1.7	1.1	2.6
	13	1.1	0.5	1.4	0.0
	14	1.5	1.2	2.0	1.3
	15	0.0	1.2	--	1.5
	16	3.1	1.2	1.8	1.1
	17	2.1	1.4	3.1	2.5
	18	3.0	0.3	0.2	1.0
	19	1.2	0.0	1.6	1.9
	20	1.6	0.9	0.4	0.3

Appendix A.4 Aboveground Biomass (g) (oven-dry basis).

Species and Parameter	Replicate	Treatment (pH) 5.6	4.6	3.6	2.6
White Spruce					
Total Biomass	1	0.90	0.70	0.85	1.97
	2	0.85	2.07	1.78	1.05
	3	1.15	1.43	0.83	0.81
	4	1.40	1.65	1.14	1.18
	5	0.65	1.30	0.91	0.83
	6	0.78	0.96	1.00	1.81
	7	1.71	1.62	1.24	0.92
	8	2.77	1.25	1.25	2.10
	9	1.79	1.08	1.84	0.91
	10	1.71	1.77	0.69	1.05
	11	1.33	1.74	1.75	1.48
	12	1.61	1.56	0.76	1.55
	13	1.53	1.28	1.22	1.52
	14	1.62	1.56	1.37	0.66
	15	0.77	1.34		1.18
	16	1.57	2.12	0.97	1.05
	17	1.42	1.70	1.79	1.11
	18	1.72	1.56	1.04	1.25
	19	1.08	0.84	0.86	1.93
	20	0.77	2.07	1.26	0.79
New Growth	1	0.46	0.34	0.35	0.86
	2	0.36	0.85	0.59	0.43
	3	0.59	0.55	0.36	0.38
	4	0.64	0.60	0.47	0.42
	5	0.33	0.44	0.46	0.37
	6	0.36	0.36	0.42	0.72
	7	0.76	0.65	0.59	0.45
	8	0.88	0.49	0.45	0.73
	9	0.71	0.59	0.69	0.40
	10	0.77	0.68	0.29	0.47
	11	0.57	0.66	0.72	0.53
	12	0.61	0.70	0.35	0.55
	13	0.68	0.56	0.58	0.62
	14	0.76	0.49	0.72	0.22
	15	0.30	0.36		0.46
	16	0.53	0.94	0.32	0.46
	17	0.45	0.62	0.59	0.41
	18	0.57	0.71	0.46	0.67
	19	0.54	0.37	0.29	0.67
	20	0.35	0.78	0.60	0.44

Appendix A.4 (Continued)

Species and Parameter	Replicate	Treatment (pH) 5.6	4.6	3.6	2.6
Aspen	1	3.30	3.69	1.16	1.95
Total Biomass	2	2.59	2.81	2.93	3.19
	3	2.14	4.54	2.00	2.90
	4	2.48	2.88	2.10	3.11
	5	1.60	2.23	2.80	2.79
	6	2.96	1.76	4.10	2.94
	7	3.23	3.39	4.45	2.97
	8	4.03	3.51	3.19	3.49
	9	4.19	4.15	3.15	3.65
	10	3.84	2.64	4.59	3.67
	11	3.29	3.82	2.48	3.75
	12	3.91	0.89	3.52	4.70
	13	5.39	4.67	3.61	4.10
	14	3.53	2.87	2.99	3.75
	15	3.20	2.26	3.30	3.23
	16	3.59	3.59	3.05	3.77
	17	3.04	1.57	4.75	3.19
	18	4.00	1.57	2.84	3.20
	19	2.67	4.31	3.50	3.89
	20	3.43	4.25	3.10	2.60
Alfalfa	1	2.21	2.22	3.54	1.25
Total Biomass	2	2.45	2.75	3.34	2.64
	3	2.62	2.44	2.54	2.21
	4	3.08	2.65	2.40	2.73
	5	1.18	2.60	3.01	1.46
	6	2.74	2.28	2.67	2.03
	7	2.30	0.93	0.38	2.29
	8	2.02	2.47	2.07	2.34
	9	1.81	1.98	2.49	1.67
	10	2.62	2.59	1.51	2.16
	11	2.23	2.74	1.90	2.59
	12	2.21	2.48	3.03	2.07
	13	2.74	2.25	3.46	1.55
	14	2.66	2.91	3.16	2.08
	15	1.96	2.25	2.33	1.50
	16	1.33	2.22	2.89	2.24
	17	2.58	2.07	3.02	2.33
	18	2.29	0.94	1.50	1.72
	19	2.05	2.85	1.94	2.42
	20	3.11	2.19	2.65	1.92

Appendix A.4 (Continued)

Species and Parameter	Replicate	Treatment (pH) 5.6	4.6	3.6	2.6
Alfalfa					
Last Cut	1	0.45	0.56	1.07	0.37
	2	0.60	0.76	0.81	0.72
	3	0.65	0.80	0.64	0.65
	4	0.68	0.60	0.55	0.65
	5	0.32	0.78	0.85	0.33
	6	0.64	0.56	0.54	0.76
	7	0.60	0.21	0.08	0.67
	8	0.48	0.56	0.40	0.75
	9	0.52	0.70	0.70	0.56
	10	0.75	0.57	0.36	0.55
	11	0.44	0.57	0.68	0.58
	12	0.54	0.56	0.90	0.60
	13	0.65	0.42	1.01	0.40
	14	0.56	0.64	1.04	0.58
	15	0.40	0.51	0.77	0.44
	16	0.32	0.74	0.62	0.50
	17	0.59	0.49	0.84	0.72
	18	0.61	0.19	0.46	0.59
	19	0.58	0.58	0.54	0.79
	20	0.85	0.54	0.76	0.60
Wheat					
Total Biomass	1	1.69	1.67	1.38	2.20
	2	1.42	1.78	1.39	1.63
	3	1.37	1.71	1.62	1.81
	4	1.62	1.84	1.33	1.71
	5	1.66	1.44	1.53	1.76
	6	1.65	1.42	1.68	1.50
	7	1.80	1.26	1.81	1.87
	8	1.34	1.42	1.55	1.77
	9	1.71	1.39	1.47	1.86
	10	1.69	1.53	1.64	1.92
	11	1.77	1.41	1.48	1.63
	12	1.54	1.64	1.55	1.78
	13	1.48	1.53	1.73	1.67
	14	1.43	1.29	1.61	2.08
	15	1.71	1.70	1.56	2.17
	16	1.92	1.46	1.76	1.95
	17	2.03	1.78	1.72	1.54
	18	1.48	1.44	1.58	2.02
	19	1.87	1.40	1.95	1.53
	20			1.58	1.19

Appendix A.4 (Continued)

Species and Parameter	Replicate	Treatment (pH) 5.6	4.6	3.6	2.6
Wheat					
Grain Weight	1	0.36	0.37	0.52	0.65
	2	0.61	0.82	0.15	0.64
	3	0.55	0.70	0.73	0.48
	4	0.67	0.60	0.52	0.70
	5	0.70	0.40	0.59	0.73
	6	0.76	0.55	0.68	0.41
	7	0.82	0.50	0.75	0.59
	8	0.52	0.56	0.67	0.55
	9	0.26	0.52	0.58	0.62
	10	0.60	0.54	0.73	0.81
	11	0.76	0.60	0.56	0.66
	12	0.63	0.53	0.65	0.67
	13	0.50	0.49	0.61	0.72
	14	0.55	0.43	0.68	0.70
	15	0.79	0.79	0.67	0.92
	16	0.59	0.53	0.71	0.77
	17	0.91	0.69	0.73	0.60
	18	0.53	0.49	0.63	0.50
	19	0.79	0.61	0.78	0.59
	20			0.68	0.30
Canola					
Total Biomass	1	1.12	1.35	1.12	1.60
	2	1.68	1.40	1.23	1.26
	3	0.96	1.25	1.40	1.10
	4	1.20	1.04	1.41	1.63
	5	1.53	1.16	1.27	2.65
	6	1.63	1.48	1.41	1.52
	7	1.75	1.68	1.34	1.91
	8	1.06	1.50	1.43	1.48
	9	1.36	1.48	1.83	2.24
	10	1.12	1.15	1.14	1.37
	11	1.60	1.33	1.55	1.20
	12	1.50	1.76	1.50	1.41
	13	1.56	1.31	1.37	1.31
	14	1.36	1.76	1.59	1.74
	15	1.12	1.53	1.33	1.21
	16	1.44	1.36	0.80	1.42
	17	1.46	1.61	1.05	2.28
	18	1.37	1.09	1.64	1.65
	19	1.56	1.34	1.27	1.72
	20	1.14	1.57	1.69	1.68

Appendix A.4 (Continued)

Species and Parameter	Replicate	Treatment (pH)			
		5.6	4.6	3.6	2.6
Canola					
Seed Weight	1	0.73	0.64	0.80	0.92
	2	0.78	0.95	0.83	0.70
	3	0.69	0.90	0.66	0.59
	4	0.52	0.70	0.91	0.74
	5	0.95	0.50	0.75	0.28
	6	0.50	0.68	0.96	0.77
	7	0.36	0.20	0.48	0.35
	8	0.71	0.54	0.70	0.90
	9	0.41	0.69	0.42	0.76
	10	0.75	0.29	0.69	0.81
	11	0.42	0.94	0.28	0.72
	12	0.64	0.57	0.32	0.79
	13	0.90	0.70	0.80	0.59
	14	0.69	0.63	0.09	0.70
	15	0.68	0.50	0.50	0.75
	16	0.68	0.66	0.63	0.75
	17	0.37	0.50	0.60	0.64
	18	0.91	0.49	0.59	0.88
	19	0.36	0.44	0.24	0.84
	20	0.67	0.67	0.53	0.87

APPENDIX B

CHLOROPHYLL CONCENTRATION

Appendix B.1 Chlorophyll Concentration - Aspen (1-80), Alfalfa (81-159).

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector, SRC
30 Campus Drive
Saskatoon, Saskatchewan S7N 0X1
Attn: L. Baschuk, E902-17

Date Samples Received: 18-Feb-86 Client P.O.:

SAMPLE	CLIENT DESCRIPTION
1419	1 #VEGETATION#
1420	2 #VEGETATION#
1421	3 #VEGETATION#
1422	4 #VEGETATION#

ANALYTE	UNITS	1419	1420	1421	1422
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	2.90	3.50	1.60	1.52
Chlorophyll B	ug/gs	0.10	1.00	0.29	<0.01

SAMPLE	CLIENT DESCRIPTION
1423	5 #VEGETATION#
1424	6 #VEGETATION#
1425	7 #VEGETATION#
1426	8 #VEGETATION#

ANALYTE	UNITS	1423	1424	1425	1426
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	1.56	1.46	3.95	2.37
Chlorophyll B	ug/gs	0.46	3.34	0.22	0.50

SAMPLE	CLIENT DESCRIPTION
1427	9 #VEGETATION#
1428	10 #VEGETATION#
1429	11 #VEGETATION#
1430	12 #VEGETATION#

ANALYTE	UNITS	1427	1428	1429	1430
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	1.81	3.29	3.18	2.55
Chlorophyll B	ug/gs	0.46	0.07	0.69	0.45

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector, SRC

SAMPLE	CLIENT DESCRIPTION
1431	13 #VEGETATION#
1432	14 #VEGETATION#
1433	15 #VEGETATION#
1434	16 #VEGETATION#

ANALYTE	UNITS	1431	1432	1433	1434
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	1.49	5.38	4.12	6.63
Chlorophyll B	ug/gs	0.49	2.50	1.63	1.93

SAMPLE	CLIENT DESCRIPTION
1435	17 #VEGETATION#
1436	18 #VEGETATION#
1437	19 #VEGETATION#
1438	20 #VEGETATION#

ANALYTE	UNITS	1435	1436	1437	1438
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	2.64	4.03	0.66	1.40
Chlorophyll B	ug/gs	0.99	1.42	0.11	0.22

SAMPLE	CLIENT DESCRIPTION
1439	21 #VEGETATION#
1440	22 #VEGETATION#
1441	23 #VEGETATION#
1442	24 #VEGETATION#

ANALYTE	UNITS	1439	1440	1441	1442
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	2.10	1.61	1.50	3.45
Chlorophyll B	ug/gs	0.34	0.65	0.34	1.36

Appendix B.1 (Continued)

SRC Group: 257 10-Mar-86 02:35 PM Page 3

SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
1443	25 #VEGETATION#
1444	26 #VEGETATION#
1445	27 #VEGETATION#
1446	28 #VEGETATION#

ANALYTE	UNITS	1443	1444	1445	1446
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	2.77	2.15	2.35	2.04
Chlorophyll B	ug/m3	1.05	0.72	0.64	0.56

SAMPLE	CLIENT DESCRIPTION
1447	29 #VEGETATION#
1448	30 #VEGETATION#
1449	31 #VEGETATION#
1450	32 #VEGETATION#

ANALYTE	UNITS	1447	1448	1449	1450
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	3.56	3.65	1.39	2.58
Chlorophyll B	ug/m3	1.37	1.41	0.36	0.80

SAMPLE	CLIENT DESCRIPTION
1451	33 #VEGETATION#
1452	34 #VEGETATION#
1453	35 #VEGETATION#
1454	36 #VEGETATION#

ANALYTE	UNITS	1451	1452	1453	1454
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	2.29	2.12	3.74	1.46
Chlorophyll B	ug/m3	0.85	0.53	1.38	0.22

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
1455	37 #VEGETATION#
1456	38 #VEGETATION#
1457	39 #VEGETATION#
1458	40 #VEGETATION#

ANALYTE	UNITS	1455	1456	1457	1458
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	2.34	3.89	4.26	3.04
Chlorophyll B	ug/m3	0.48	1.47	1.52	1.26

SAMPLE	CLIENT DESCRIPTION
1459	41 #VEGETATION#
1460	42 #VEGETATION#
1461	43 #VEGETATION#
1462	44 #VEGETATION#

ANALYTE	UNITS	1459	1460	1461	1462
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	3.13	7.35	0.55	1.23
Chlorophyll B	ug/m3	1.15	2.67	0.24	0.63

SAMPLE	CLIENT DESCRIPTION
1463	45 #VEGETATION#
1464	46 #VEGETATION#
1465	47 #VEGETATION#
1466	48 #VEGETATION#

ANALYTE	UNITS	1463	1464	1465	1466
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	3.47	0.95	2.22	5.40
Chlorophyll B	ug/m3	1.22	0.29	0.86	1.74

Appendix B.1 (Continued)

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
1467	49 #VEGETATION#
1468	50 #VEGETATION#
1469	51 #VEGETATION#
1470	52 #VEGETATION#

ANALYTE	UNITS	1467	1468	1469	1470
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	4.53	0.96	3.67	3.49
Chlorophyll B	ug/m2	1.74	0.33	1.19	1.17

SAMPLE	CLIENT DESCRIPTION
1471	53 #VEGETATION#
1472	54 #VEGETATION#
1473	55 #VEGETATION#
1474	56 #VEGETATION#

ANALYTE	UNITS	1471	1472	1473	1474
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	2.21	2.10	1.96	1.47
Chlorophyll B	ug/m2	0.55	0.38	0.47	0.35

SAMPLE	CLIENT DESCRIPTION
1475	57 #VEGETATION#
1476	58 #VEGETATION#
1477	59 #VEGETATION#
1478	60 #VEGETATION#

ANALYTE	UNITS	1475	1476	1477	1478
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	1.51	1.56	2.59	2.43
Chlorophyll B	ug/m2	0.43	0.49	0.90	0.63

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
1479	61 #VEGETATION#
1480	62 #VEGETATION#
1481	63 #VEGETATION#
1482	64 #VEGETATION#

ANALYTE	UNITS	1479	1480	1481	1482
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	3.15	2.47	1.39	1.85
Chlorophyll B	ug/m2	1.03	0.67	0.62	0.56

SAMPLE	CLIENT DESCRIPTION
1483	65 #VEGETATION#
1484	66 #VEGETATION#
1485	67 #VEGETATION#
1486	68 #VEGETATION#

ANALYTE	UNITS	1483	1484	1485	1486
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	1.87	3.33	2.09	1.52
Chlorophyll B	ug/m2	0.69	1.26	0.63	0.68

SAMPLE	CLIENT DESCRIPTION
1487	69 #VEGETATION#
1488	70 #VEGETATION#
1489	71 #VEGETATION#
1490	72 #VEGETATION#

ANALYTE	UNITS	1487	1488	1489	1490
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	2.20	3.06	0.47	2.40
Chlorophyll B	ug/m2	0.68	1.17	0.04	1.06

Appendix B.1 (Continued)

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT	DESCRIPTION
1491	73	#VEGETATION#
1492	74	#VEGETATION#
1493	75	#VEGETATION#
1494	76	#VEGETATION#

ANALYTE	UNITS	1491	1492	1493	1494
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	1.48	1.75	3.27	1.61
Chlorophyll B	ug/m2	0.35	0.76	1.25	0.96

SAMPLE	CLIENT	DESCRIPTION
1495	77	#VEGETATION#
1496	78	#VEGETATION#
1497	79	#VEGETATION#
1498	80	#VEGETATION#

ANALYTE	UNITS	1495	1496	1497	1498
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	3.24	3.14	3.00	0.34
Chlorophyll B	ug/m2	1.46	1.35	1.64	0.33

SAMPLE	CLIENT	DESCRIPTION
1499	81	#VEGETATION#
1500	82	#VEGETATION#
1501	83	#VEGETATION#
1502	84	#VEGETATION#

ANALYTE	UNITS	1499	1500	1501	1502
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	1.25	1.94	1.57	0.18
Chlorophyll B	ug/m2	0.61	0.67	0.44	0.09

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT	DESCRIPTION
1503	85	#VEGETATION#
1504	86	#VEGETATION#
1505	87	#VEGETATION#
1506	88	#VEGETATION#

ANALYTE	UNITS	1503	1504	1505	1506
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	1.15	1.89	1.33	2.22
Chlorophyll B	ug/m2	0.10	0.22	0.54	0.60

SAMPLE	CLIENT	DESCRIPTION
1507	89	#VEGETATION#
1508	90	#VEGETATION#
1509	91	#VEGETATION#
1510	92	#VEGETATION#

ANALYTE	UNITS	1507	1508	1509	1510
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	2.00	4.37	1.43	1.98
Chlorophyll B	ug/m2	0.44	0.92	1.05	1.11

SAMPLE	CLIENT	DESCRIPTION
1511	93	#VEGETATION#
1512	94	#VEGETATION#
1513	95	#VEGETATION#
1514	96	#VEGETATION#

ANALYTE	UNITS	1511	1512	1513	1514
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	3.71	1.38	1.53	2.10
Chlorophyll B	ug/m2	2.38	0.71	0.75	1.24

Appendix B.1 (Continued)

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT	DESCRIPTION
1515	97	#VEGETATION#
1516	98	#VEGETATION#
1517	99	#VEGETATION#
1518	100	#VEGETATION#

ANALYTE	UNITS	1515	1516	1517	1518
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	2.51	4.51	0.61	2.02
Chlorophyll B	ug/m3	0.94	1.74	0.23	0.90

SAMPLE	CLIENT	DESCRIPTION
1519	101	#VEGETATION#
1520	102	#VEGETATION#
1521	103	#VEGETATION#
1522	104	#VEGETATION#

ANALYTE	UNITS	1519	1520	1521	1522
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	3.19	2.22	0.84	0.89
Chlorophyll B	ug/m3	1.43	1.09	0.29	0.16

SAMPLE	CLIENT	DESCRIPTION
1523	105	#VEGETATION#
1524	106	#VEGETATION#
1525	107	#VEGETATION#
1526	108	#VEGETATION#

ANALYTE	UNITS	1523	1524	1525	1526
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	2.18	3.67	5.17	2.65
Chlorophyll B	ug/m3	0.58	1.00	1.06	0.86

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT	DESCRIPTION
1527	109	#VEGETATION#
1528	110	#VEGETATION#
1529	111	#VEGETATION#
1530	112	#VEGETATION#

ANALYTE	UNITS	1527	1528	1529	1530
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	2.88	4.98	3.80	3.51
Chlorophyll B	ug/m3	1.29	1.73	1.20	0.84

SAMPLE	CLIENT	DESCRIPTION
1531	113	#VEGETATION#
1532	114	#VEGETATION#
1533	115	#VEGETATION#
1534	116	#VEGETATION#

ANALYTE	UNITS	1531	1532	1533	1534
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	2.72	5.51	4.14	3.32
Chlorophyll B	ug/m3	0.90	2.57	1.37	0.61

SAMPLE	CLIENT	DESCRIPTION
1535	117	#VEGETATION#
1536	118	#VEGETATION#
1537	119	#VEGETATION#
1538	120	#VEGETATION#

ANALYTE	UNITS	1535	1536	1537	1538
TRACE CONSTITUENTS					
Chlorophyll A	ug/m3	2.65	5.29	1.83	2.73
Chlorophyll B	ug/m3	0.55	1.07	0.44	0.54

Appendix B.1 (Continued)

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT	DESCRIPTION
1539	121	#VEGETATION#
1540	122	#VEGETATION#
1541	123	#VEGETATION#
1542	124	#VEGETATION#

ANALYTE	UNITS	1539	1540	1541	1542
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	2.38	0.55	0.98	1.70
Chlorophyll B	ug/gs	0.45	0.05	0.08	0.14

SAMPLE	CLIENT	DESCRIPTION
1543	125	#VEGETATION#
1544	126	#VEGETATION#
1545	127	#VEGETATION#
1546	128	#VEGETATION#

ANALYTE	UNITS	1543	1544	1545	1546
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	1.03	2.62	0.75	2.98
Chlorophyll B	ug/gs	0.16	0.39	0.01	0.54

SAMPLE	CLIENT	DESCRIPTION
1547	129	#VEGETATION#
1548	130	#VEGETATION#
1549	131	#VEGETATION#
1550	132	#VEGETATION#

ANALYTE	UNITS	1547	1548	1549	1550
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	0.98	5.40	4.27	1.36
Chlorophyll B	ug/gs	0.01	1.35	1.31	0.16

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT	DESCRIPTION
1551	133	#VEGETATION#
1552	134	#VEGETATION#
1553	135	#VEGETATION#
1554	136	#VEGETATION#

ANALYTE	UNITS	1551	1552	1553	1554
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	7.43	2.95	1.66	6.85
Chlorophyll B	ug/gs	2.80	0.79	0.36	2.50

SAMPLE	CLIENT	DESCRIPTION
1555	137	#VEGETATION#
1556	138	#VEGETATION#
1557	139	#VEGETATION#
1558	140	#VEGETATION#

ANALYTE	UNITS	1555	1556	1557	1558
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	2.58	1.48	2.03	3.71
Chlorophyll B	ug/gs	0.46	0.02	0.31	0.88

SAMPLE	CLIENT	DESCRIPTION
1559	141	#VEGETATION#
1560	142	#VEGETATION#
1561	143	#VEGETATION#
1562	144	#VEGETATION#

ANALYTE	UNITS	1559	1560	1561	1562
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	2.93	2.58	1.41	5.16
Chlorophyll B	ug/gs	0.76	0.65	0.12	1.05

Appendix B.1 (Continued)

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT	DESCRIPTION
1563	145	#VEGETATION#
1564	146	#VEGETATION#
1565	147	#VEGETATION#
1566	148	#VEGETATION#

ANALYTE	UNITS	1563	1564	1565	1566
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	1.31	5.20	3.62	2.22
Chlorophyll B	ug/gs	0.51	1.39	1.32	0.64

SAMPLE	CLIENT	DESCRIPTION
1567	149	#VEGETATION#
1568	150	#VEGETATION#
1569	151	#VEGETATION#
1570	152	#VEGETATION#

ANALYTE	UNITS	1567	1568	1569	1570
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	7.06	4.88	3.51	4.26
Chlorophyll B	ug/gs	2.37	1.68	1.39	1.63

SAMPLE	CLIENT	DESCRIPTION
1571	153	#VEGETATION#
1572	154	#VEGETATION#
1573	155	#VEGETATION#
1574	156	#VEGETATION#

ANALYTE	UNITS	1571	1572	1573	1574
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	2.34	1.49	3.32	7.33
Chlorophyll B	ug/gs	0.83	0.44	1.12	2.88

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT	DESCRIPTION
1575	157	#VEGETATION#
1576	158	#VEGETATION#
1577	159	#VEGETATION#

ANALYTE	UNITS	1575	1576	1577
TRACE CONSTITUENTS				
Chlorophyll A	ug/gs	0.14	5.95	2.42
Chlorophyll B	ug/gs	0.32	1.90	0.96

Appendix B.2 Chlorophyll Concentration - White Spruce.

SRC Group: 859 05-Jun-86 09:21 AM Page 1

SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC
15 Innovation Blvd.
Saskatoon, Saskatchewan S7N 2X8
Attn: L. Baschak, E902-17

Date Samples Received: 14-May-86 Client P.O.:

SAMPLE	CLIENT DESCRIPTION
6927	S1 (WHITE SPRUCE) #VEGETATION#
6928	S2 #VEGETATION#
6929	S3 #VEGETATION#
6930	S4 #VEGETATION#

ANALYTE	UNITS	6927	6928	6929	6930
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	1.29	2.79	2.86	1.10
Chlorophyll B	ug/gs	0.79	1.07	0.92	0.41

SAMPLE	CLIENT DESCRIPTION
6931	S5 #VEGETATION#
6932	S6 #VEGETATION#
6933	S7 #VEGETATION#
6934	S8 #VEGETATION#

ANALYTE	UNITS	6931	6932	6933	6934
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	2.41	1.23	3.58	3.29
Chlorophyll B	ug/gs	0.58	0.85	0.83	0.63

SAMPLE	CLIENT DESCRIPTION
6935	S9 #VEGETATION#
6936	S10 #VEGETATION#
6937	S11 #VEGETATION#
6938	S12 #VEGETATION#

ANALYTE	UNITS	6935	6936	6937	6938
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	1.67	1.27	1.70	3.93
Chlorophyll B	ug/gs	0.51	0.85	0.81	1.59

SRC Group: 859 05-Jun-86 09:21 AM Page 2

SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
6939	S13 #VEGETATION#
6940	S14 #VEGETATION#
6941	S15 #VEGETATION#
6942	S16 #VEGETATION#

ANALYTE	UNITS	6939	6940	6941	6942
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	3.49	4.75	2.32	3.22
Chlorophyll B	ug/gs	0.97	6.95	0.65	0.62

SAMPLE	CLIENT DESCRIPTION
6943	S17 #VEGETATION#
6944	S18 #VEGETATION#
6945	S19 #VEGETATION#
6946	S20 #VEGETATION#

ANALYTE	UNITS	6943	6944	6945	6946
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	2.38	4.11	2.09	1.01
Chlorophyll B	ug/gs	0.71	1.26	0.75	0.49

SAMPLE	CLIENT DESCRIPTION
6947	S21 #VEGETATION#
6948	S22 #VEGETATION#
6949	S23 #VEGETATION#
6950	S24 #VEGETATION#

ANALYTE	UNITS	6947	6948	6949	6950
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	4.53	1.90	2.37	2.39
Chlorophyll B	ug/gs	1.30	0.72	0.57	0.63

Appendix B.2 (Continued)

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT	DESCRIPTION
6951	S25	#VEGETATION#
6952	S26	#VEGETATION#
6953	S27	#VEGETATION#
6954	S28	#VEGETATION#

ANALYTE	UNITS	6951	6952	6953	6954
TRACE CONSTITUENTS					
Chlorophyll A	ug/mg	2.57	1.49	3.43	4.01
Chlorophyll B	ug/mg	0.61	0.73	1.01	1.18

SAMPLE	CLIENT	DESCRIPTION
6955	S29	#VEGETATION#
6956	S30	#VEGETATION#
6957	S31	#VEGETATION#
6958	S32	#VEGETATION#

ANALYTE	UNITS	6955	6956	6957	6958
TRACE CONSTITUENTS					
Chlorophyll A	ug/mg	3.93	2.70	1.79	2.03
Chlorophyll B	ug/mg	0.48	0.23	0.15	0.39

SAMPLE	CLIENT	DESCRIPTION
6959	S33	#VEGETATION#
6960	S34	#VEGETATION#
6961	S35	#VEGETATION#
6962	S36	#VEGETATION#

ANALYTE	UNITS	6959	6960	6961	6962
TRACE CONSTITUENTS					
Chlorophyll A	ug/mg	4.37	2.07	3.08	1.66
Chlorophyll B	ug/mg	0.12	0.30	0.64	0.24

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT	DESCRIPTION
6963	S37	#VEGETATION#
6964	S38	#VEGETATION#
6965	S39	#VEGETATION#
6966	S40	#VEGETATION#

ANALYTE	UNITS	6963	6964	6965	6966
TRACE CONSTITUENTS					
Chlorophyll A	ug/mg	4.61	2.58	2.80	2.97
Chlorophyll B	ug/mg	0.87	0.27	0.50	0.46

SAMPLE	CLIENT	DESCRIPTION
6967	S41	#VEGETATION#
6968	S42	#VEGETATION#
6969	S43	#VEGETATION#
6970	S44	#VEGETATION#

ANALYTE	UNITS	6967	6968	6969	6970
TRACE CONSTITUENTS					
Chlorophyll A	ug/mg	4.62	2.14	3.19	3.15
Chlorophyll B	ug/mg	0.93	0.18	0.1	0.48

SAMPLE	CLIENT	DESCRIPTION
6971	S45	#VEGETATION#
6972	S46	#VEGETATION#
6973	S47	#VEGETATION#
6974	S48	#VEGETATION#

ANALYTE	UNITS	6971	6972	6973	6974
TRACE CONSTITUENTS					
Chlorophyll A	ug/mg	1.43	3.35	2.38	2.66
Chlorophyll B	ug/mg	0.1	0.28	0.31	0.94

Appendix B.2 (Continued)

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
6975	S49 #VEGETATION#
6976	S50 #VEGETATION#
6977	S51 #VEGETATION#
6978	S52 #VEGETATION#

ANALYTE	UNITS	6975	6976	6977	6978
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	3.94	2.04	1.35	4.41
Chlorophyll B	ug/gs	2.41	1.27	0.30	2.16

SAMPLE	CLIENT DESCRIPTION
6979	S53 #VEGETATION#
6980	S54 #VEGETATION#
6981	S55 #VEGETATION#
6982	S56 #VEGETATION#

ANALYTE	UNITS	6979	6980	6981	6982
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	5.05	4.05	3.61	2.73
Chlorophyll B	ug/gs	2.14	1.98	1.00	1.65

SAMPLE	CLIENT DESCRIPTION
6983	S57 #VEGETATION#
6984	S58 #VEGETATION#
6985	S59 #VEGETATION#
6986	S61 #VEGETATION#

ANALYTE	UNITS	6983	6984	6985	6986
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	5.67	3.24	3.75	1.02
Chlorophyll B	ug/gs	2.47	1.47	1.11	0.99

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
6987	S62 #VEGETATION#
6988	S63 #VEGETATION#
6989	S64 #VEGETATION#
6990	S65 #VEGETATION#

ANALYTE	UNITS	6987	6988	6989	6990
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	2.37	2.69	1.38	1.89
Chlorophyll B	ug/gs	1.70	2.23	1.19	1.54

SAMPLE	CLIENT DESCRIPTION
6991	S66 #VEGETATION#
6992	S67 #VEGETATION#
6993	S68 #VEGETATION#
6994	S69 #VEGETATION#

ANALYTE	UNITS	6991	6992	6993	6994
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	3.54	1.97	1.80	3.08
Chlorophyll B	ug/gs	2.31	0.79	1.91	1.67

SAMPLE	CLIENT DESCRIPTION
6995	S70 #VEGETATION#
6996	S71 #VEGETATION#
6997	S72 #VEGETATION#
6998	S73 #VEGETATION#

ANALYTE	UNITS	6995	6996	6997	6998
TRACE CONSTITUENTS					
Chlorophyll A	ug/gs	1.42	1.25	3.27	1.04
Chlorophyll B	ug/gs	0.82	1.14	1.72	1.08

Appendix B.2 (Continued)

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector, SRC

SAMPLE	CLIENT DESCRIPTION
6999	S74 #VEGETATION#
7000	S75 #VEGETATION#
7001	S76 #VEGETATION#
7002	S77 #VEGETATION#

ANALYTE	UNITS	6999	7000	7001	7002
TRACE CONSTITUENTS					
Chlorophyll A	ug/m2	2.57	3.49	4.02	3.00
Chlorophyll B	ug/m2	1.60	1.57	2.23	1.63

SAMPLE	CLIENT DESCRIPTION
7003	S78 #VEGETATION#
7004	S79 #VEGETATION#
7005	S80 #VEGETATION#

ANALYTE	UNITS	7003	7004	7005
TRACE CONSTITUENTS				
Chlorophyll A	ug/m2	2.42	2.09	2.75
Chlorophyll B	ug/m2	1.27	1.30	2.06

APPENDIX C

FOLIAR INJURY

Appendix C.1 Foliar Injury - White Spruce.

Date and Treatment	Percentage of Plants Affected	Number of Plants with Necrotic or Chlorotic Needle Tips	Number of Needles Affected*		
			Necrotic Lesions (1-2 mm)	Necrotic Areas (>2 mm)	Total
February 27					
Treatment (pH)					
5.6	10		2		2
4.6	5			2	2
3.6	5	5		1	1
2.6	25		5	6	11
April 25					
Treatment (pH)					
5.6	15	3	1		1
4.6	5		1		1
3.6	25		1		1
2.6	75	3	9	31	40
May 14					
Treatment (pH)					
5.6	30	5	1		1
4.6	20	2		2	2
3.6	40	7		1	1
2.6	90	7	27	46	73

*In addition to needle tips.

Appendix C.2 Foliar Injury - Aspen. (Number of necrotic spots per sampled aspen leaf.)

Observation Date	Replicate	Treatment (pH)			
		5.6	4.6	3.6	2.6
December 11	1	2	0	17	10
	2	0	0	0	3
	3	2	0	2	0
	4	3	0	1	3
	5	2	0	0	1
	6	0	4	0	2
	7	0	0	0	14
	8	0	1	0	0
	9	1	0	0	2
	10	0	1	0	0
	11	0	0	5	3
	12	0	1	0	6
	13	0	0	0	3
	14	0	0	0	0
	15	0	0	0	6
	16	0	0	0	2
	17	0	0	0	0
	18	1	2	0	2
	19	0	0	0	6
	20	0	0	0	2

Appendix C.3 Foliar Injury - Alfalfa. (Number of leaflets with visible symptoms of injury.)

Observation Date	Replicate	Treatment (pH)			
		5.6	4.6	3.6	2.6
December 19	1				--
	2				4
	3			1	4
	4				--
	5				1
	6				8
	7				3
	8				3
	9				3
	10				3
	11				6
	12				3
	13		1		2
	14	1			4
	15				2
	16				1
	17				--
	18			1	3
	19				10
	20				1
January 20	1				6
	2				24
	3	1			13
	4	2			41
	5				3
	6			1	41
	7				35
	8				29
	9				17
	10				11
	11				13
	12				13
	13				2
	14	1			16
	15				15
	16				6
	17				15
	18				20
	19				36
	20				3

APPENDIX D

FOLIAGE NUTRIENT CONTENT

Appendix D.1 Plant Nutrient Data - White Spruce.*

Date Samples Received: 26-May-86 Client P.O.:

SAMPLE	CLIENT DESCRIPTION
7633	1 (WHITE SPRUCE) #VEGETATION#
7634	2 #VEGETATION#
7635	3 #VEGETATION#
7636	4 #VEGETATION#

ANALYTE	UNITS	7633	7634	7635	7636
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.5	1.6	1.5	1.5
K, flame	%	0.66	0.50	0.50	0.46
Mg, by A.A.	%	0.26	0.31	0.30	0.28
S, total	%	0.14	0.17	0.20	0.19
NUTRIENTS					
N, total Kjeld.	%	2.76	3.16	2.88	2.59
P, total as P	%	0.39	0.45	0.53	0.45

SAMPLE	CLIENT DESCRIPTION
7637	5 #VEGETATION#
7638	6 #VEGETATION#
7639	7 #VEGETATION#
7640	8 #VEGETATION#

ANALYTE	UNITS	7637	7638	7639	7640
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.4	1.1	1.5	1.4
K, flame	%	0.55	0.45	0.49	0.36
Mg, by A.A.	%	0.26	0.19	0.26	0.24
S, total	%	0.17	0.12	0.17	0.17
NUTRIENTS					
N, total Kjeld.	%	3.29	2.88	3.21	2.90
P, total as P	%	0.48	0.35	0.40	0.37

Environment Sector, SRC

SAMPLE	CLIENT DESCRIPTION
7641	9 #VEGETATION#
7642	10 #VEGETATION#
7643	11 #VEGETATION#
7644	12 #VEGETATION#

ANALYTE	UNITS	7641	7642	7643	7644
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.3	1.5	2.0	1.5
K, flame	%	0.49	0.64	0.43	0.54
Mg, by A.A.	%	0.25	0.29	0.27	0.33
S, total	%	0.13	0.19	0.19	0.25
NUTRIENTS					
N, total Kjeld.	%	2.29	2.69	2.71	2.91
P, total as P	%	0.29	0.35	0.51	0.41

SAMPLE	CLIENT DESCRIPTION
7645	13 #VEGETATION#
7646	14 #VEGETATION#
7647	15 #VEGETATION#
7648	16 #VEGETATION#

ANALYTE	UNITS	7645	7646	7647	7648
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.4	1.3	1.4	1.4
K, flame	%	0.60	0.44	0.48	0.51
Mg, by A.A.	%	0.29	0.24	0.24	0.27
S, total	%	0.15	0.28	0.25	0.15
NUTRIENTS					
N, total Kjeld.	%	2.96	3.16	2.71	2.89
P, total as P	%	0.37	0.34	0.33	0.28

SAMPLE	CLIENT DESCRIPTION
7649	17 #VEGETATION#
7650	18 #VEGETATION#
7651	19 #VEGETATION#
7652	20 #VEGETATION#

ANALYTE	UNITS	7649	7650	7651	7652
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.3	1.2	1.8	1.2
K, flame	%	0.58	0.47	0.59	0.52
Mg, by A.A.	%	0.26	0.24	0.33	0.28
S, total	%	0.22	0.23	0.20	0.20
NUTRIENTS					
N, total Kjeld.	%	3.40	3.17	3.19	3.08
P, total as P	%	0.38	0.52	0.34	0.31

*Each value is derived from a composite of two subsamples.

Appendix D.2 Plant Nutrient Data - Aspen.*

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC
30 Campus Drive
Saskatoon: Saskatchewan S7N 0X1
Attn: L. Baschuk: E902-17

Date Samples Received: 26-Feb-86 Client P.O.:

SAMPLE	CLIENT DESCRIPTION
1918	1 (ASPEN LEAVES) #VEGETATION#
1919	2 #VEGETATION#
1920	3 #VEGETATION#
1921	4 #VEGETATION#

ANALYTE	UNITS	1918	1919	1920	1921
MAJOR CONSTITUENTS					
Ca: by A.A.	%	2.5	2.2	2.7	2.7
K: flame	%	1.8	1.3	1.9	1.7
Mg: by A.A.	%	0.54	0.51	0.59	0.58
S: total	%	0.31	0.43	0.40	0.36
NUTRIENTS					
N: total Kjeld.	%	1.8	1.7	1.8	1.5
P: total as P	%	0.20	0.22	0.19	0.17

SAMPLE	CLIENT DESCRIPTION
1922	5 #VEGETATION#
1923	6 #VEGETATION#
1924	7 #VEGETATION#
1925	8 #VEGETATION#

ANALYTE	UNITS	1922	1923	1924	1925
MAJOR CONSTITUENTS					
Ca: by A.A.	%	2.6	2.4	1.4	1.5
K: flame	%	1.5	1.3	0.79	0.87
Mg: by A.A.	%	0.50	0.48	0.32	0.30
S: total	%	0.51	0.47	0.44	0.41
NUTRIENTS					
N: total Kjeld.	%	1.8	1.7	1.8	1.6
P: total as P	%	0.18	0.20	0.23	0.22

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
1926	9 #VEGETATION#
1927	10 #VEGETATION#
1928	11 #VEGETATION#
1929	12 #VEGETATION#

ANALYTE	UNITS	1926	1927	1928	1929
MAJOR CONSTITUENTS					
Ca: by A.A.	%	1.5	1.5	1.3	2.4
K: flame	%	1.0	0.74	0.81	1.5
Mg: by A.A.	%	0.38	0.36	0.30	0.60
S: total	%	0.48	0.43	0.50	0.48
NUTRIENTS					
N: total Kjeld.	%	1.8	1.9	1.4	1.6
P: total as P	%	0.19	0.20	0.21	0.19

SAMPLE	CLIENT DESCRIPTION
1930	13 #VEGETATION#
1931	14 #VEGETATION#
1932	15 #VEGETATION#
1933	16 #VEGETATION#

ANALYTE	UNITS	1930	1931	1932	1933
MAJOR CONSTITUENTS					
Ca: by A.A.	%	2.2	2.4	2.3	2.4
K: flame	%	1.4	2.2	1.5	1.6
Mg: by A.A.	%	0.49	0.50	0.54	0.48
S: total	%	0.40	0.37	0.54	0.46
NUTRIENTS					
N: total Kjeld.	%	1.7	1.7	1.8	1.8
P: total as P	%	0.22	0.17	0.20	0.14

*Each value is derived from a composite of two subsamples.

Appendix D.2 (Continued)

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector, SRC

SAMPLE	CLIENT DESCRIPTION
1934	17 #VEGETATION#
1935	18 #VEGETATION#
1936	19 #VEGETATION#
1937	20 #VEGETATION#

ANALYTE	UNITS	1934	1935	1936	1937
MAJOR CONSTITUENTS					
Ca, by A.A.	%	2.1	2.5	2.5	2.5
K, flame	%	1.4	1.1	1.4	2.0
Mg, by A.A.	%	0.44	0.55	0.55	0.56
S, total	%	0.39	0.40	0.40	0.47
NUTRIENTS					
N, total Kjeld.	%	1.6	1.5	1.3	2.0
P, total as P	%	0.16	0.16	0.17	0.16

SAMPLE	CLIENT DESCRIPTION
1933	21 #VEGETATION#
1938	22 #VEGETATION#
1940	23 #VEGETATION#
1941	24 #VEGETATION#

ANALYTE	UNITS	1938	1939	1940	1941
MAJOR CONSTITUENTS					
Ca, by A.A.	%	2.4	2.3	2.3	2.3
K, flame	%	1.2	1.6	1.8	1.6
Mg, by A.A.	%	0.53	0.49	0.41	0.55
S, total	%	0.55	0.40	0.37	0.60
NUTRIENTS					
N, total Kjeld.	%	1.6	1.5	1.7	2.0
P, total as P	%	0.17	0.19	0.16	0.24

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector, SRC

SAMPLE	CLIENT DESCRIPTION
1942	25 #VEGETATION#
1943	26 #VEGETATION#
1944	27 #VEGETATION#
1945	28 #VEGETATION#

ANALYTE	UNITS	1942	1943	1944	1945
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.4	1.6	1.6	1.4
K, flame	%	0.96	1.1	1.2	1.3
Mg, by A.A.	%	0.25	0.30	0.29	0.26
S, total	%	0.43	0.42	0.45	0.43
NUTRIENTS					
N, total Kjeld.	%	2.0	1.8	1.9	1.7
P, total as P	%	0.19	0.20	0.23	0.16

SAMPLE	CLIENT DESCRIPTION
1946	29 #VEGETATION#
1947	30 #VEGETATION#
1948	31 #VEGETATION#
1949	32 #VEGETATION#

ANALYTE	UNITS	1946	1947	1948	1949
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.6	2.5	2.4	2.2
K, flame	%	1.3	1.6	1.4	1.3
Mg, by A.A.	%	0.29	0.42	0.52	0.48
S, total	%	0.40	0.42	0.46	0.43
NUTRIENTS					
N, total Kjeld.	%	1.9	2.0	1.9	1.7
P, total as P	%	0.17	0.20	0.19	0.20

Appendix D.2 (Continued)

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
1950	33 #VEGETATION#
1951	34 #VEGETATION#
1952	35 #VEGETATION#
1953	36 #VEGETATION#

ANALYTE	UNITS	1950	1951	1952	1953
MAJOR CONSTITUENTS					
Ca: by A.A.	%	2.3	2.3	2.5	2.6
K: flame	%	1.6	1.1	1.9	1.8
Mg: by A.A.	%	0.52	0.51	0.50	0.54
S: total	%	0.42	0.51	0.48	0.43
NUTRIENTS					
N: total Kjeld.	%	1.3	1.7	1.9	1.9
P: total as P	%	0.16	0.18	0.16	0.15

SAMPLE	CLIENT DESCRIPTION
1954	37 #VEGETATION#
1955	38 #VEGETATION#
1956	39 #VEGETATION#
1957	40 #VEGETATION#

ANALYTE	UNITS	1954	1955	1956	1957
MAJOR CONSTITUENTS					
Ca: by A.A.	%	2.6	2.3	2.4	2.2
K: flame	%	1.8	1.8	1.7	1.2
Mg: by A.A.	%	0.50	0.40	0.47	0.45
S: total	%	0.52	0.39	0.44	0.43
NUTRIENTS					
N: total Kjeld.	%	1.8	1.7	1.8	1.5
P: total as P	%	0.15	0.18	0.15	0.20

Appendix D.3 Plant Nutrient Data - Alfalfa.*

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC
[illegible] Campus Drive
Saskatoon, Saskatchewan S7N 0X1
[illegible] L. Baschak, E902-17

Date Samples Received: 26-Mar-86 Client P.O.:

SAMPLE	CLIENT DESCRIPTION
3197	41 #VEGETATION#
3198	42 #VEGETATION#
3199	43 #VEGETATION#
3200	44 #VEGETATION#

ANALYTE	UNITS	3197	3198	3199	3200
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.3	1.1	1.3	1.3
P, Plasma	%	2.8	3.5	2.6	2.2
Mg, by A.A.	%	0.37	0.31	0.33	0.29
S, total	%	0.18	0.33	0.33	0.23
NUTRIENTS					
N, total Kjeld.	%	3.4	3.5	3.3	3.4
P, total as P	%	0.25	0.24	0.27	0.23

SAMPLE	CLIENT DESCRIPTION
3201	45 #VEGETATION#
3202	46 #VEGETATION#
3203	47 #VEGETATION#
3204	48 #VEGETATION#

ANALYTE	UNITS	3201	3202	3203	3204
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.2	1.3	1.2	1.2
P, Plasma	%	3.8	4.2	3.2	2.5
Mg, by A.A.	%	0.30	0.30	0.34	0.23
S, total	%	0.34	0.20	0.27	0.32
NUTRIENTS					
N, total Kjeld.	%	3.1	3.3	3.3	2.9
P, total as P	%	0.26	0.24	0.31	0.24

*Each value is derived from a composite of two subsamples.

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
3205	49 #VEGETATION#
3206	50 #VEGETATION#
3207	51 #VEGETATION#
3208	52 #VEGETATION#

ANALYTE	UNITS	3205	3206	3207	3208
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.4	1.6	1.2	1.4
P, Plasma	%	3.2	4.4	3.0	4.4
Mg, by A.A.	%	0.39	0.44	0.36	0.34
S, total	%	0.33	0.38	0.23	0.36
NUTRIENTS					
N, total Kjeld.	%	3.1	3.3	3.5	3.2
P, total as P	%	0.28	0.28	0.28	0.30

SAMPLE	CLIENT DESCRIPTION
3209	53 #VEGETATION#
3210	54 #VEGETATION#
3211	55 #VEGETATION#
3212	56 #VEGETATION#

ANALYTE	UNITS	3209	3210	3211	3212
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.3	1.4	1.3	1.4
P, Plasma	%	2.6	3.3	3.7	3.1
Mg, by A.A.	%	0.40	0.32	0.33	0.32
S, total	%	0.38	0.34	0.28	0.39
NUTRIENTS					
N, total Kjeld.	%	3.5	4.0	3.2	3.9
P, total as P	%	0.21	0.22	0.25	0.23

Appendix D.3 (Continued)

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
3213	57 #VEGETATION#
3214	58 #VEGETATION#
3215	59 #VEGETATION#
3216	60 #VEGETATION#

ANALYTE	UNITS	3213	3214	3215	3216
MAJOR CONSTITUENTS					
Ca: by A.A.	%	1.4	1.9	1.5	1.4
K: flame	%	3.0	3.5	2.8	3.7
Mg: by A.A.	%	0.30	0.50	0.39	0.32
S: total	%	0.40	0.31	0.29	0.41
NUTRIENTS					
N: total Kjeld.	%	3.6	3.5	3.2	3.5
P: total as P	%	0.19	0.25	0.29	0.28

SAMPLE	CLIENT DESCRIPTION
3217	61 #VEGETATION#
3218	62 #VEGETATION#
3219	63 #VEGETATION#
3220	64 #VEGETATION#

ANALYTE	UNITS	3217	3218	3219	3220
MAJOR CONSTITUENTS					
Ca: by A.A.	%	1.5	1.0	1.5	1.7
K: flame	%	3.7	3.0	2.8	4.8
Mg: by A.A.	%	0.32	0.35	0.24	0.41
S: total	%	0.36	0.36	0.39	0.37
NUTRIENTS					
N: total Kjeld.	%	3.4	4.2	3.5	3.0
P: total as P	%	0.26	0.23	0.29	0.29

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SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
3221	65 #VEGETATION#
3222	66 #VEGETATION#
3223	67 #VEGETATION#
3224	68 #VEGETATION#

ANALYTE	UNITS	3221	3222	3223	3224
MAJOR CONSTITUENTS					
Ca: by A.A.	%	1.3	1.3	1.2	1.5
K: flame	%	3.4	3.1	2.9	2.8
Mg: by A.A.	%	0.34	0.35	0.34	0.31
S: total	%	0.37	0.30	0.32	0.36
NUTRIENTS					
N: total Kjeld.	%	3.9	3.2	3.5	3.6
P: total as P	%	0.35	0.29	0.24	0.26

SAMPLE	CLIENT DESCRIPTION
3225	69 #VEGETATION#
3226	70 #VEGETATION#
3227	71 #VEGETATION#
3228	72 #VEGETATION#

ANALYTE	UNITS	3225	3226	3227	3228
MAJOR CONSTITUENTS					
Ca: by A.A.	%	1.4	1.5	1.3	1.4
K: flame	%	2.9	2.3	1.9	2.1
Mg: by A.A.	%	0.34	0.37	0.31	0.33
S: total	%	0.44	0.38	0.32	0.40
NUTRIENTS					
N: total Kjeld.	%	2.5	3.4	3.8	4.2
P: total as P	%	0.28	0.26	0.23	0.30

Appendix D.3 (Continued)

SRC Group: 503 15-Apr-86 08:21 AM Page 5

SASKATCHEWAN RESEARCH COUNCIL

Environment Sector: SRC

SAMPLE	CLIENT DESCRIPTION
3229	73 #VEGETATION#
3230	74 #VEGETATION#
3231	75 #VEGETATION#
3232	76 #VEGETATION#

ANALYTE	UNITS	3229	3230	3231	3232
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.5	1.4	1.6	1.2
K, flame	%	3.1	2.8	2.2	2.3
Mg, by A.A.	%	0.35	0.35	0.36	0.31
S, total	%	0.31	0.31	0.31	0.40
NUTRIENTS					
N, total Kjeld.	%	4.22	3.90	4.19	4.31
P, total as P	%	0.28	0.29	0.27	0.30

SAMPLE	CLIENT DESCRIPTION
3233	77 #VEGETATION#
3234	78 #VEGETATION#
3235	79 #VEGETATION#
3236	80 #VEGETATION#

ANALYTE	UNITS	3233	3234	3235	3236
MAJOR CONSTITUENTS					
Ca, by A.A.	%	1.4	1.6	1.6	1.1
K, flame	%	2.6	3.0	2.5	1.1
Mg, by A.A.	%	0.42	0.44	0.41	0.29
S, total	%	0.45	0.37	0.30	0.39
NUTRIENTS					
N, total Kjeld.	%	4.17	4.35	4.27	2.75
P, total as P	%	0.26	0.31	0.28	0.24

APPENDIX E

BELOWGROUND BIOMASS

Appendix E.1 Belowground Biomass (g).

Species	Replicate	Treatment (pH)			
		5.6	4.6	3.6	2.6
White Spruce	1	1.00	1.22	0.71	0.52
	2	1.10	0.73	0.80	0.67
	3	0.44	0.74	0.65	0.56
	4	0.81	0.87	0.28	0.82
	5	1.00	0.77	0.83	0.96
	6	0.32	0.94	0.50	0.50
Alfalfa	1	0.95	1.02	1.02	0.73
	2	0.52	0.79	1.19	0.61
	3	0.58	0.87	0.51	0.47
	4	0.73	0.55	1.08	0.43
	5	1.11	0.60	0.97	0.62
	6	1.08	0.67	0.52	0.78
Wheat	1	0.16	0.12	0.16	0.14
	2	0.17	0.15	0.13	0.10
	3	0.14	0.15	0.15	0.08
	4	0.09	0.09	0.20	0.12
	5	0.10	0.09	0.11	0.11
	6	0.09	0.11	0.15	0.06
Canola	1	0.32	0.46	0.42	0.58
	2	0.46	0.47	0.34	0.43
	3	0.40	0.40	0.20	0.37
	4	0.41	0.44	0.31	0.45
	5	0.28	0.53	0.37	0.45
	6	0.40	0.36	0.42	0.45

APPENDIX F

SOILS DATA

Appendix F.1 Soil Chemistry Data.

Date: 18-07-86
SRC-BASCHUK#I6-0359 0382

SASKATCHEWAN SOIL TESTING LABORATORY
FERTILITY ANALYSIS
###SRC - BASCHAK###

Page: 1 of 1

Lab Number	Client Identification	Te ture	pH	Conduct dS/m	NO3-N ppm	P ppm	K ppm	SO4-S ppm
I6-0359	E-902-17-100	Sandy Loam	6.2	0.3	6.0	5.5	90	12
I6-0360	E-902-17-101	Sandy Loam	6.3	0.2	4.0	5.5	90	10.0
I6-0361	E-902-17-102	Sandy Loam	6.4	0.2	4.0	6.0	135	5.0
I6-0362	E-902-17-103	Sandy Loam	6.4	0.2	5.0	5.0	95	5.0
I6-0363	E-902-17-104	Sandy Loam	6.4	0.2	3.5	4.5	90	5.0
I6-0364	E-902-17-105	Sandy Loam	6.4	0.2	5.5	4.5	90	4.5
I6-0365	E-902-17-106	Sandy Loam	6.4	0.2	2.5	5.5	90	6.0
I6-0366	E-902-17-107	Sandy Loam	6.3	0.2	3.0	5.0	85	8.0
I6-0367	E-902-17-108	Sandy Loam	6.3	0.2	5.0	5.0	90	5.5
I6-0368	E-902-17-109	Sandy Loam	6.4	0.2	4.5	5.0	90	6.0
I6-0369	E-902-17-110	Sandy Loam	6.4	0.2	3.5	5.0	90	4.5
I6-0370	E-902-17-111	Sandy Loam	6.4	0.2	3.5	5.0	95	5.5
I6-0371	E-902-17-112	Sandy Loam	6.4	0.2	3.5	5.5	95	5.5
I6-0372	E-902-17-113	Sandy Loam	6.4	0.2	3.5	5.5	90	5.0
I6-0373	E-902-17-114	Sandy Loam	6.4	0.2	4.0	5.0	90	5.0
I6-0374	E-902-17-115	Sandy Loam	6.4	0.2	5.0	5.0	90	6.5
I6-0375	E-902-17-116	Sandy Loam	6.4	0.2	3.0	5.5	90	6.0
I6-0376	E-902-17-117	Sandy Loam	6.4	0.2	4.0	5.0	95	5.5
I6-0377	E-902-17-118	Sandy Loam	5.9	0.4	11.0	6.0	90	12
I6-0378	E-902-17-119	Sandy Loam	5.9	0.4	11.5	6.0	90	12
I6-0379	E-902-17-120	Sandy Loam	5.9	0.4	9.0	5.5	85	12
I6-0380	E-902-17-121	Sandy Loam	5.9	0.4	7.0	5.5	90	12
I6-0381	E-902-17-122	Sandy Loam	5.9	0.4	6.0	5.0	75	12
I6-0382	E-902-17-123	Sandy Loam	5.9	0.4	6.5	5.0	85	12

Comment:

###End###

Date: 22-07-86
SRC-BASCHUK#I6-0359/0382

SASKATCHEWAN SOIL TESTING LABORATORY
NH4OAc EXCHANGEABLE CATIONS
###SRC - BASCHAK###

Page: 1 of 1

Lab Number	Client Identification	Ca ppm	Mg ppm	Na ppm	K ppm
I6-0359	E-902-17-100	2048	269	20	130
I6-0360	E-902-17-101	2048	282	20	130
I6-0361	E-902-17-102	2048	256	30	100
I6-0362	E-902-17-103	2176	282	20	100
I6-0363	E-902-17-104	2176	282	30	100
I6-0364	E-902-17-105	1920	256	30	90
I6-0365	E-902-17-106	1920	256	30	130
I6-0366	E-902-17-107	2176	294	30	100
I6-0367	E-902-17-108	2048	269	20	100
I6-0368	E-902-17-109	2048	269	30	100
I6-0369	E-902-17-110	2176	294	30	110
I6-0370	E-902-17-111	2048	269	30	90
I6-0371	E-902-17-112	2176	282	30	130
I6-0372	E-902-17-113	2048	269	30	100
I6-0373	E-902-17-114	2048	269	20	110
I6-0374	E-902-17-115	2176	282	30	100
I6-0375	E-902-17-116	2048	269	30	110
I6-0376	E-902-17-117	2048	269	20	110
I6-0377	E-902-17-118	2048	256	20	100
I6-0378	E-902-17-119	1920	256	30	100
I6-0379	E-902-17-120	1920	269	20	90
I6-0380	E-902-17-121	2048	269	20	100
I6-0381	E-902-17-122	1920	256	20	30
I6-0382	E-902-17-123	1920	243	40	30

Comment:

###End###

Appendix F.1 (Continued)

SASKATCHEWAN SOIL TESTING LABORATORY
SALINITY ANALYSIS
AC - EASCHAR###

Page: 1 of 1

Lab #	Client Identification	% Sat	pH	CONC. (mS/cm)	IONS IN SATURATION EXTRACT (meq/L) Ca++	Mg++	Na+	K+	Cl-	SO4=	S.A.R.
[illegible]	E-902-17-101	53	6.2	0.5	14	50	19	12	9	55	0.4
Ia-0206	E-902-17-101	53	6.2	0.4	11	55	19	11	10	48	0.3
Ia-0241	E-902-17-102	52	6.3	0.3	10	41	18	10	7	28	0.3
[illegible]	E-902-17-103	51	6.2	0.4	10	41	20	10	9	26	0.3
Ia-0283	E-902-17-104	53	6.3	0.3	9	47	15	11	9	25	0.3
Ia-0264	E-902-17-105	52	6.3	0.4	10	52	18	10	9	23	0.3
Ia-0285	E-902-17-106	53	6.3	0.4	11	49	15	11	7	35	0.4
Ia-0214	E-902-17-107	51	6.2	0.4	11	57	19	10	9	48	0.3
Ia-0287	E-902-17-108	52	6.2	0.4	9	51	18	10	10	35	0.3
Ia-0230	E-902-17-109	49	6.2	0.4	11	50	22	11	11	39	0.3
Ia-0289	E-902-17-110	51	6.2	0.3	10	43	17	10	10	28	0.3
Ia-0270	E-902-17-111	51	6.2	0.4	17	41	19	12	10	27	0.6
Ia-0271	E-902-17-112	52	6.2	0.4	11	51	18	10	12	27	0.3
Ia-0272	E-902-17-113	52	6.3	0.4	12	50	15	10	13	26	0.4
Ia-0273	E-902-17-114	51	6.3	0.4	12	50	15	10	11	26	0.4
Ia-0274	E-902-17-115	53	6.2	0.4	12	54	17	11	13	26	0.4
Ia-0275	E-902-17-116	52	6.3	0.4	10	50	15	11	12	31	0.3
Ia-0276	E-902-17-117	53	6.3	0.3	9	47	15	11	10	24	0.3
Ia-0277	E-902-17-118	51	5.7	0.9	13	102	41	15	13	120	0.3
Ia-0278	E-902-17-119	52	5.7	0.9	12	105	37	16	12	120	0.2
Ia-0279	E-902-17-120	53	5.8	0.9	12	106	35	14	14	150	0.3
Ia-0280	E-902-17-121	52	5.8	1.0	14	123	41	15	14	220	0.2
Ia-0281	E-902-17-122	50	5.8	0.9	13	116	38	15	13	220	0.3
Ia-0282	E-902-17-123	50	5.7	0.9	13	120	40	13	11	220	0.3

###End###

APPENDIX G

SOIL LEACHATE CHEMISTRY DATA

Appendix G.1 Soil Leachate Chemistry Data.

SASKATCHEWAN SOIL TESTING LABORATORY
Date: 16-07-86 WATER ANALYSIS Page: 1 of 4
SFC-BUSCHUK#W6-0001/0084 ***SFC - BASCHAK***

Lab #	Client Identification	IONS IN SATURATION EXTRACT(meq/L) Na+	Ca++	Mg++	K+	Cl-	SO4=	HCO3-	CATIONS (meq/L)	ANIONS (meq/L)	SALTS (meq/L)	S.A.R.
W6-0001	1	0.3	1.2	0.7	0.3	0.3	0.4	-	2.5	0.7	1.5	0.4
W6-0002	2	0.4	1.7	1.1	0.3	0.5	0.6	-	3.5	1.0	2.2	0.4
W6-0003	3	0.3	1.2	0.8	0.3	0.3	0.6	-	2.6	0.9	1.7	0.3
W6-0004	4	0.4	2.7	1.5	0.4	0.3	2.3	-	5.0	2.6	4.3	0.3
W6-0005	5	0.3	1.1	0.5	0.3	0.3	0.5	-	2.3	0.7	1.6	0.4
W6-0006	6	0.3	1.2	0.6	0.3	0.3	0.5	-	2.4	0.9	1.7	0.4
W6-0007	7	0.3	1.4	0.7	0.3	0.3	0.7	-	2.8	1.0	2.0	0.3
W6-0008	8	0.4	2.8	1.6	0.4	0.3	2.2	-	5.1	2.5	4.5	0.3
W6-0009	9	0.3	1.0	0.5	0.3	0.3	0.4	-	2.1	0.7	1.5	0.4
W6-0010	10	0.3	1.1	0.5	0.3	0.3	0.5	-	2.2	0.7	1.6	0.3
W6-0011	11	0.3	1.2	0.6	0.3	0.3	0.6	-	2.3	0.9	1.8	0.3
W6-0012	12	0.3	2.4	1.3	0.4	0.2	2.0	-	4.4	2.2	3.8	0.3
W6-0013	13	0.3	1.0	0.5	0.3	0.3	0.4	-	2.0	0.7	1.6	0.4
W6-0014	14	0.3	1.0	0.5	0.3	0.3	0.4	-	2.1	0.7	1.6	0.3
W6-0015	15	0.4	1.2	0.6	0.3	0.3	0.5	-	2.5	0.9	1.7	0.4
W6-0016	16	0.3	2.5	1.5	0.3	0.2	2.2	-	4.6	2.4	4.1	0.2
W6-0017	17	0.3	1.2	0.6	0.3	0.3	0.5	-	2.4	0.8	1.8	0.3
W6-0018	18	0.3	0.8	0.4	0.3	0.3	0.5	-	1.8	0.7	1.3	0.3
W6-0019	19	0.3	1.5	0.7	0.3	0.3	0.7	-	2.8	1.0	2.3	0.3
W6-0020	20	0.3	2.9	1.5	0.4	0.3	2.2	-	5.1	2.5	4.6	0.2
W6-0021	21	0.3	1.4	0.8	0.3	0.3	0.5	-	2.8	0.9	2.1	0.3
W6-0022	22	0.3	1.0	0.5	0.3	0.3	0.5	-	1.9	0.7	1.5	0.3
W6-0023	23	0.3	0.9	0.4	0.2	0.2	0.5	-	1.9	0.8	1.5	0.3
W6-0024	24	0.3	2.5	1.4	0.3	0.2	2.4	-	4.6	2.6	4.3	0.2
W6-0025	25	0.3	1.2	0.6	0.3	0.3	0.5	-	2.4	0.8	1.8	0.4

Comment:

SASKATCHEWAN SOIL TESTING LABORATORY
Date: 16-07-86 WATER ANALYSIS Page: 2 of 4
SFC-BUSCHUK#W6-0001/0084 ***SFC - BASCHAK***

Lab #	Client Identification	IONS IN SATURATION EXTRACT(meq/L) Na+	Ca++	Mg++	K+	Cl-	SO4=	HCO3-	CATIONS (meq/L)	ANIONS (meq/L)	SALTS (meq/L)	S.A.R.
W6-0026	26	0.3	1.1	0.5	0.2	0.3	0.5	-	2.1	0.8	1.6	0.4
W6-0027	27	0.3	1.4	0.6	0.3	0.4	0.6	-	2.6	1.0	2.0	0.3
W6-0028	28	0.3	2.4	1.4	0.3	0.3	2.3	-	4.5	2.6	4.1	0.2
W6-0029	29	0.3	1.0	0.5	0.2	0.3	0.5	-	2.0	0.8	1.5	0.4
W6-0030	30	0.4	2.2	1.1	0.3	0.5	0.8	-	4.1	1.3	2.8	0.3
W6-0031	31	0.3	1.1	0.5	0.2	0.2	0.8	-	2.2	1.0	1.7	0.4
W6-0032	32	0.3	3.0	1.7	0.3	0.2	3.1	-	5.4	3.3	4.8	0.2
W6-0033	33	0.3	1.2	0.5	0.2	0.2	0.5	-	2.3	0.7	1.6	0.3
W6-0034	34	0.3	1.1	0.5	0.2	0.2	0.6	-	2.2	0.8	1.6	0.3
W6-0035	35	0.3	1.0	0.5	0.2	0.2	0.7	-	2.0	0.9	1.6	0.3
W6-0036	36	0.3	3.5	1.8	0.3	0.3	3.2	-	5.9	3.6	5.6	0.2
W6-0037	37	0.3	0.8	0.4	0.2	0.2	0.4	-	1.7	0.6	1.3	0.3
W6-0038	38	0.3	1.1	0.5	0.2	0.4	0.6	-	2.1	1.0	1.6	0.3
W6-0039	39	0.3	1.1	0.5	0.2	0.2	0.8	-	2.1	1.0	1.7	0.3
W6-0040	40	0.3	2.8	1.6	0.3	0.2	2.6	-	5.0	2.8	4.4	0.2
W6-0041	41	0.3	1.0	0.5	0.2	0.2	0.5	-	2.0	0.8	1.5	0.3
W6-0042	42	0.3	0.9	0.4	0.2	0.2	0.6	-	1.7	0.8	1.4	0.3
W6-0043	43	0.3	2.0	1.3	0.3	0.4	0.8	-	3.9	1.2	2.7	0.3
W6-0044	44	0.3	3.1	1.7	0.3	0.2	3.0	-	5.4	3.2	4.8	0.2
W6-0045	45	0.3	0.9	0.4	0.2	0.3	0.5	-	1.8	0.8	1.5	0.3
W6-0046	46	0.3	0.8	0.4	0.2	0.2	0.5	-	1.7	0.8	1.2	0.3
W6-0047	47	0.3	1.4	0.7	0.3	0.3	0.8	-	2.6	1.1	2.0	0.3
W6-0048	48	0.4	3.6	1.9	0.3	0.3	3.1	-	6.2	3.4	5.5	0.2
W6-0049	49	0.4	0.9	0.4	0.2	0.2	0.5	-	1.9	0.7	1.2	0.5
W6-0050	50	0.4	1.0	0.5	0.2	0.2	0.6	-	2.1	0.8	1.4	0.5

Comment:

Appendix G.1 (Continued)

Date: 16-07-86
SRC-BUSCHUK:W6-0001/0084

SASKATCHEWAN SOIL TESTING LABORATORY
WATER ANALYSIS
SRC - BASCHAK

Page: 3 of 4

Lab #	Client Identification	IONS IN SATURATION EXTRACT(meq/L) Mg+	Ca++	Mg++	K+	Cl-	SO4=	HCO3-	CATIONS (meq/L)	ANIONS (meq/L)	SALTS (meq/L)	S.A.R.
W6-0051	51	0.4	1.3	0.6	0.2	0.3	0.7	-	2.5	1.0	1.7	0.4
W6-0052	52	0.5	3.1	1.7	0.3	0.2	3.0	-	5.6	3.2	4.6	0.3
W6-0053	53	0.4	0.9	0.4	0.2	0.3	0.5	-	2.0	0.8	1.3	0.5
W6-0054	54	0.4	1.1	0.5	0.2	0.3	0.6	-	2.2	0.8	1.6	0.4
W6-0055	55	0.4	1.4	0.6	0.3	0.3	0.8	-	2.7	1.0	2.0	0.4
W6-0056	56	0.4	3.6	1.9	0.3	0.3	3.2	-	6.2	3.5	5.4	0.3
W6-0057	57	0.4	1.0	0.4	0.1	0.2	0.6	-	1.9	0.8	1.4	0.5
W6-0058	58	0.4	2.6	1.3	0.3	0.1	1.3	-	4.6	1.4	3.2	0.3
W6-0059	59	0.4	1.1	0.5	0.2	0.2	0.9	-	2.3	1.1	1.7	0.5
W6-0060	60	0.4	3.5	2.0	0.2	0.2	3.9	-	6.1	4.1	5.3	0.2
W6-0061	61	0.4	1.2	0.6	0.2	0.1	0.6	-	2.4	0.8	1.6	0.5
W6-0062	62	0.4	1.2	0.5	0.2	0.2	0.7	-	2.4	0.9	1.8	0.4
W6-0063	63	0.4	1.3	0.6	0.2	0.6	0.9	-	2.4	1.5	1.9	0.4
W6-0064	64	0.6	4.2	2.2	0.2	0.2	4.0	-	7.1	4.2	6.4	0.2
W6-0065	65	0.3	1.0	0.4	0.2	0.1	0.5	-	2.0	0.7	1.3	0.4
W6-0066	66	0.4	1.2	0.6	0.2	0.2	0.7	-	2.3	0.9	1.7	0.4
W6-0067	67	0.4	1.2	0.6	0.2	0.2	0.8	-	2.3	1.0	1.7	0.5
W6-0068	68	0.4	3.7	1.9	0.2	0.1	3.5	-	6.3	3.7	5.3	0.3
W6-0069	69	0.3	1.0	0.5	0.2	0.2	0.6	-	2.0	0.8	1.5	0.4
W6-0070	70	0.4	1.0	0.4	0.2	0.2	0.6	-	2.0	0.8	1.6	0.5
W6-0071	71	0.5	2.8	1.3	0.2	0.1	1.1	-	4.8	1.2	3.0	0.4
W6-0072	72	0.5	3.7	2.0	0.2	0.1	3.0	-	6.3	3.7	5.4	0.3
W6-0073	73	0.4	1.2	0.5	0.2	0.2	0.6	-	2.2	0.8	1.6	0.4
W6-0074	74	0.3	0.8	0.4	0.2	0.1	0.5	-	1.6	0.7	1.2	0.3
W6-0075	75	0.4	1.4	0.6	0.2	0.2	0.9	-	2.6	1.1	2.1	0.4

Comments:

Date: 16-07-86
SRC-BUSCHUK:W6-0001/0084

SASKATCHEWAN SOIL TESTING LABORATORY
WATER ANALYSIS
SRC - BASCHAK

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Lab #	Client Identification	IONS IN SATURATION EXTRACT(meq/L) Mg+	Ca++	Mg++	K+	Cl-	SO4=	HCO3-	CATIONS (meq/L)	ANIONS (meq/L)	SALTS (meq/L)	S.A.P.
W6-0076	76	0.5	4.4	2.3	0.2	0.2	4.2	-	7.3	4.4	6.4	0.3
W6-0077	77	0.4	1.0	0.4	0.2	0.1	0.6	-	2.0	0.8	1.4	0.5
W6-0078	78	0.3	0.8	0.4	0.2	0.2	0.	-	1.7	0.7	1.3	0.4
W6-0079	79	0.4	1.1	0.5	0.1	0.1	0.9	-	2.2	1.0	1.6	0.4
W6-0080	80	0.4	3.7	1.9	0.2	0.2	3.7	-	6.2	3.8	5.5	0.3
W6-0081	81	0.3	0.9	0.4	0.2	0.1	0.5	-	1.8	0.7	1.3	0.4
W6-0082	82	0.5	1.2	0.6	0.2	0.2	0.7	-	2.4	0.8	1.8	0.5
W6-0083	83	0.3	1.2	0.6	0.2	0.2	0.9	-	2.3	1.0	1.9	0.4
W6-0084	84	0.4	4.2	2.2	0.2	0.2	4.0	-	7.0	4.1	6.3	0.2

Comments:

End

Appendix G.1 (Continued)

SASKATCHEWAN SOIL TESTING LABORATORY
WATER ANALYSIS
SPC - BASCHAK

Date: 16-07-86
SPC-BUSCHUK\W6-0001/0084

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Lab #	Client Identification	T.D.S.	pH	COND. (mS/cm)	CONCENTRATION OF SOLUBLE IONS (ug/mL) Na+	Ca++	Mg++	K+	Cl-	SO4=	HCO3-	S.A.R.
W6-0001	1	109	6.3	0.2	8	24	8	10	10	21	-	0.4
W6-0002	2	160	6.9	0.3	10	33	13	12	16	28	-	0.4
W6-0003	3	128	6.3	0.2	8	25	10	10	10	30	-	0.3
W6-0004	4	294	6.4	0.5	9	55	18	15	10	110	-	0.3
W6-0005	5	115	6.4	0.2	8	23	6	10	10	22	-	0.4
W6-0006	6	128	6.5	0.2	8	24	7	11	11	26	-	0.4
W6-0007	7	147	6.1	0.2	8	28	9	11	12	32	-	0.3
W6-0008	8	307	6.4	0.5	9	56	19	14	9	108	-	0.3
W6-0009	9	109	6.4	0.2	8	20	6	10	10	21	-	0.4
W6-0010	10	115	6.4	0.2	7	22	7	10	10	22	-	0.3
W6-0011	11	134	6.3	0.2	7	24	7	11	10	29	-	0.3
W6-0012	12	262	6.3	0.4	9	48	16	14	8	94	-	0.3
W6-0013	13	115	6.3	0.2	7	20	6	10	10	21	-	0.4
W6-0014	14	115	6.7	0.2	7	21	6	10	10	21	-	0.3
W6-0015	15	128	7.2	0.2	9	25	7	10	12	26	-	0.4
W6-0016	16	282	6.2	0.4	7	50	18	13	8	105	-	0.2
W6-0017	17	134	6.6	0.2	7	25	7	10	12	22	-	0.3
W6-0018	18	96	6.5	0.2	6	17	5	10	10	23	-	0.3
W6-0019	19	166	6.2	0.3	7	30	9	12	12	33	-	0.3
W6-0020	20	314	6.2	0.5	9	58	19	15	11	107	-	0.2
W6-0021	21	154	6.2	0.2	7	28	10	11	12	26	-	0.3
W6-0022	22	109	6.5	0.2	6	20	5	10	10	22	-	0.3
W6-0023	23	109	6.5	0.2	6	19	5	9	9	26	-	0.3
W6-0024	24	294	6.1	0.5	7	51	17	13	9	114	-	0.2
W6-0025	25	134	7.1	0.2	8	25	7	10	12	23	-	0.4

Comment:

SASKATCHEWAN SOIL TESTING LABORATORY
WATER ANALYSIS
SPC - BASCHAK

Date: 16-07-86
SPC-BUSCHUK\W6-0001/0084

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Lab #	Client Identification	T.D.S.	pH	COND. (mS/cm)	CONCENTRATION OF SOLUBLE IONS (ug/mL) Na+	Ca++	Mg++	K+	Cl-	SO4=	HCO3-	S.A.R.
W6-0026	26	122	7.1	0.2	9	22	6	9	12	23	-	0.4
W6-0027	27	147	7.3	0.2	8	27	8	11	13	31	-	0.3
W6-0028	28	282	6.8	0.4	7	49	17	13	10	112	-	0.2
W6-0029	29	109	7.0	0.2	7	21	6	9	10	25	-	0.4
W6-0030	30	198	7.6	0.3	10	45	13	12	16	39	-	0.3
W6-0031	31	128	6.7	0.2	8	22	6	8	8	38	-	0.4
W6-0032	32	326	6.3	0.5	8	61	21	11	8	150	-	0.2
W6-0033	33	115	7.0	0.2	7	25	6	9	8	24	-	0.3
W6-0034	34	122	6.6	0.2	7	23	6	9	8	28	-	0.3
W6-0035	35	122	6.8	0.2	6	21	6	9	7	35	-	0.3
W6-0036	36	378	6.3	0.6	9	70	22	12	11	156	-	0.2
W6-0037	37	96	6.3	0.2	6	17	4	8	7	21	-	0.3
W6-0038	38	122	6.3	0.2	7	23	6	8	14	27	-	0.3
W6-0039	39	128	6.9	0.2	9	23	6	9	7	37	-	0.3
W6-0040	40	301	6.2	0.5	7	56	19	11	7	127	-	0.2
W6-0041	41	109	6.6	0.2	6	21	6	8	9	26	-	0.3
W6-0042	42	102	6.4	0.2	6	18	5	7	9	27	-	0.3
W6-0043	43	192	7.6	0.3	8	40	15	13	13	40	-	0.3
W6-0044	44	326	6.6	0.5	7	62	21	12	9	142	-	0.2
W6-0045	45	109	6.8	0.2	6	19	5	7	9	25	-	0.3
W6-0046	46	90	6.4	0.1	7	17	5	7	7	26	-	0.4
W6-0047	47	147	6.8	0.2	8	27	9	10	10	38	-	0.3
W6-0048	48	371	6.7	0.6	9	72	23	13	11	150	-	0.2
W6-0049	49	90	6.5	0.1	10	18	5	9	6	24	-	0.5
W6-0050	50	102	6.3	0.2	10	20	5	8	7	27	-	0.5

Comment:

Appendix G.1 (Continued)

Date: 16-07-86
SPC-BUSCHUK#W6-0001/0084

SASKATCHEWAN SOIL TESTING LABORATORY
WATER ANALYSIS
###SRC - BASCHAK###

Lab #	Client Identification	T.D.S.	pH	COND. (mS/cm)	CONCENTRATION OF SOLUBLE IONS (ug/mL) Na+	Ca++	Mg++	K+	Cl-	SO4=	HCO3-	S.A.R.
W6-0051	51	128	7.0	0.2	9	25	7	9	9	36	-	0.4
W6-0052	52	314	6.4	0.5	11	62	21	12	8	142	-	0.3
W6-0053	53	96	7.1	0.2	9	19	5	9	11	24	-	0.5
W6-0054	54	122	7.2	0.2	9	23	6	9	10	27	-	0.4
W6-0055	55	147	7.2	0.2	10	27	8	10	9	37	-	0.4
W6-0056	56	365	7.1	0.6	10	72	23	13	11	153	-	0.3
W6-0057	57	102	6.9	0.2	9	20	5	5	6	30	-	0.5
W6-0058	58	224	8.0	0.3	10	52	16	10	5	62	-	0.3
W6-0059	59	129	6.9	0.2	10	23	7	6	7	43	-	0.5
W6-0060	60	358	6.0	0.6	9	71	24	7	6	189	-	0.2
W6-0061	61	122	6.9	0.2	10	25	7	7	5	31	-	0.5
W6-0062	62	139	6.8	0.2	9	25	7	6	7	32	-	0.4
W6-0063	63	141	6.6	0.2	9	25	7	6	22	41	-	0.4
W6-0064	64	422	6.5	0.7	10	94	27	8	6	194	-	0.2
W6-0065	65	96	7.0	0.2	8	21	5	6	5	26	-	0.4
W6-0066	66	128	6.5	0.2	9	25	7	6	6	33	-	0.4
W6-0067	67	129	6.2	0.2	10	24	7	6	6	40	-	0.5
W6-0068	68	358	6.1	0.6	10	74	23	8	5	170	-	0.3
W6-0069	69	109	6.9	0.2	8	21	5	7	6	29	-	0.4
W6-0070	70	115	6.1	0.2	9	21	5	6	7	30	-	0.5
W6-0071	71	211	8.2	0.3	12	56	15	9	4	51	-	0.4
W6-0072	72	365	6.3	0.6	11	74	24	7	5	173	-	0.3
W6-0073	73	122	6.3	0.2	9	24	6	6	6	31	-	0.4
W6-0074	74	90	5.9	0.1	6	17	5	6	5	26	-	0.3
W6-0075	75	154	6.9	0.2	10	27	8	7	6	44	-	0.4

Comment:

Date: 16-07-86
SPC-BUSCHUK#W6-0001/0084

SASKATCHEWAN SOIL TESTING LABORATORY
WATER ANALYSIS
###SRC - BASCHAK###

Lab #	Client Identification	T.D.S.	pH	COND. (mS/cm)	CONCENTRATION OF SOLUBLE IONS (ug/mL) Na+	Ca++	Mg++	K+	Cl-	SO4=	HCO3-	S.A.R.
W6-0076	76	422	6.1	0.7	11	87	28	8	6	202	-	0.3
W6-0077	77	102	6.5	0.2	9	20	5	6	5	29	-	0.5
W6-0078	78	96	6.5	0.2	8	17	5	6	6	27	-	0.4
W6-0079	79	122	6.2	0.2	9	23	6	5	5	41	-	0.4
W6-0080	80	371	6.1	0.6	10	74	23	7	6	176	-	0.3
W6-0081	81	96	6.7	0.2	7	19	5	6	5	26	-	0.4
W6-0082	82	134	6.5	0.2	11	25	7	6	6	32	-	0.5
W6-0083	83	141	6.6	0.2	8	25	7	6	6	41	-	0.4
W6-0084	84	416	6.2	0.6	10	83	27	8	6	191	-	0.2

Comment:

###End###

APPENDIX H

STATISTICAL ANALYSIS

Appendix H.1 Analysis of Variance for the Plant Data.

Source of Variation	df	SS	Mean Square	F
PLANT GROWTH - WHITE SPRUCE				
February 27th Measurement				
Between treatments	3	0.458	0.153	0.207
Within treatments (error)	75	55.293	0.737	
May 14th Measurement				
Between treatments	3	0.291	0.097	0.130
Within treatments (error)	75	55.943	0.746	
PLANT GROWTH - ALFALFA				
January 21st Measurement				
Between treatments	3	215.850	71.950	3.224
Within treatments (error)	76	1696.100	22.317	
March 3rd Measurement				
Between treatments	3	79.553	26.518	2.485
Within treatments (error)	76	811.066	10.672	
April 14th Measurement				
Between treatments	3	412.216	137.405	7.126
Within treatments (error)	76	1465.376	19.281	
May 1st Measurement				
Between treatments	3	647.878	215.959	4.627
Within treatments (error)	76	3547.410	46.676	
LEAF MEASUREMENTS - WHEAT				
Top Leaf Length				
Between treatments	3	39.603	13.201	0.582
Within treatments (error)	74	1677.791	22.673	

Appendix H.1 (Continued)

Source of Variation	df	SS	Mean Square	F
LEAF MEASUREMENTS - CANOLA				
Leaf Length				
Between treatments	3	7.035	2.345	3.067
Within treatments (error)	76	58.105	0.765	
Leaf Width				
Between treatments	3	7.025	2.342	4.086
Within treatments (error)	76	43.555	0.573	
ABOVEGROUND BIOMASS - WHITE SPRUCE				
Total Biomass				
Between treatments				
Within treatments (error)				
New Growth				
Between treatments	3	0.119	0.040	1.578
Within treatments (error)	75	1.883	0.025	
ABOVEGROUND BIOMASS - ASPEN				
Total Biomass				
Between treatments	7	1.668	0.556	0.684
Within treatments (error)	76	61.759	0.813	
ABOVEGROUND BIOMASS - ALFALFA				
Last Cut				
Between treatments	3	0.184	0.061	2.001
Within treatments (error)	76	2.336	0.031	
Total Biomass				
Between treatments	3	1.877	0.626	1.900
Within treatments (error)	76	25.032	0.329	

Appendix H.1 (Continued)

Source of Variation	df	SS	Mean Square	F
ABOVEGROUND BIOMASS - WHEAT				
Total Biomass				
Between treatments	3	0.649	0.216	5.740
Within treatments (error)	74	2.789	0.038	
Grain Weight				
Between treatments	3	0.061	0.020	1.040
Within treatments (error)	74	1.451	0.020	
ABOVEGROUND BIOMASS - CANOLA				
Total Biomass				
Between treatments	3	0.847	0.282	3.606
Within treatments (error)	76	5.950	0.078	
Seed Weight				
Between treatments	3	0.191	0.064	1.658
Within treatments (error)	76	2.914	0.038	
CHLOROPHYLL CONCENTRATION - WHITE SPRUCE				
Chlorophyll a				
Between treatments	3	14.423	4.808	4.288
Within treatments (error)	75	84.088	1.121	
Chlorophyll b				
Between treatments	3	10.026	3.342	4.186
Within treatments (error)	75	59.874	0.798	
CHLOROPHYLL CONCENTRATION - ASPEN				
Chlorophyll a				
Between treatments	3	4.211	1.404	0.845
Within treatments (error)	76	126.246	1.661	

Appendix H.1 (Continued)

Source of Variation	df	SS	Mean Square	F
Chlorophyll b				
Between treatments	3	0.146	0.049	0.120
Within treatments (error)	76	30.887	0.406	
CHLOROPHYLL CONCENTRATION - ALFALFA				
Chlorophyll a				
Between treatments	3	27.417	9.139	3.343
Within treatments (error)	75	205.018	2.734	
Chlorophyll b				
Between treatments	3	3.129	1.043	2.330
Within treatments (error)	75	33.566	0.448	
FOLIAR INJURY - WHITE SPRUCE				
February 27th Observation				
Between treatments	3	2.850	0.950	1.946
Within treatments (error)	76	37.100	0.488	
April 25th Observation				
Between treatments	3	57.037	19.012	13.781
Within treatments (error)	76	104.850	1.380	
May 14th Observation				
Between treatments	3	187.300	62.433	13.615
Within treatments (error)	76	348.500	4.586	
FOLIAR INJURY - ASPEN				
December 11th Observation				
Between treatments	3	101.350	33.783	4.478
Within treatments (error)	76	573.400	7.545	

Appendix H.1 (Continued)

Source of Variation	df	SS	Mean Square	F
Final Observation				
Between treatments	3	3015.738	1005.246	3.111
Within treatments (error)	76	24559.750	323.155	
FOLIAR INJURY - ALFALFA				
December 19th Observation				
Between treatments	3	133.537	44.512	25.893
Within treatments (error)	76	130.650	1.719	
January 20th Observation				
Between treatments	3	4788.691	1596.230	40.722
Within treatments (error)	76	2979.100	39.199	
PLANT ANALYSIS - ASPEN				
Ca				
Between treatments	3	1.100	0.367	2.191
Within treatments (error)	36	6.024	0.167	
K				
Between treatments	3	0.443	0.148	1.189
Within treatments (error)	36	4.469	0.124	
Mg				
Between treatments	3	0.090	0.030	3.582
Within treatments (error)	36	0.303	0.008	
S				
Between treatments	3	0.004	0.001	0.420
Within treatments (error)	36	0.121	0.003	
N				
Between treatments	3	0.147	0.049	1.554
Within treatments (error)	36	1.133	0.031	

Appendix H.1 (Continued)

Source of Variation	df	SS	Mean Square	F
P				
Between treatments	3	0.005	0.002	2.900
Within treatments (error)	36	0.020	0.001	
PLANT ANALYSIS - WHITE SPRUCE				
Ca				
Between treatments	3	0.113	0.038	0.870
Within treatments (error)	6	0.696	0.044	
K				
Between treatments	3	0.012	0.004	0.647
Within treatments (error)	6	0.096	0.006	
Mg				
Between treatments	3	0.004	0.001	1.243
Within treatments (error)	16	0.018	0.001	
S				
Between treatments	3	0.013	0.004	3.449
Within treatments (error)	16	0.021	0.001	
N				
Between treatments	3	0.331	0.110	1.658
Within treatments (error)	16	1.066	0.067	
P				
Between treatments	3	0.034	0.011	2.511
Within treatments (error)	16	0.073	0.005	
PLANT ANALYSIS - ALFALFA				
Ca				
Between treatments	3	0.101	0.034	1.069
Within treatments (error)	36	1.134	0.032	

Appendix H.1 (Continued)

Source of Variation	df	SS	Mean Square	F
K				
Between treatments	3	5.906	1.969	4.809
Within treatments (error)	36	14.738	0.409	
Mg				
Between treatments	3	0.006	0.002	0.696
Within treatments (error)	36	0.104	0.003	
S				
Between treatments	3	0.033	0.011	3.551
Within treatments (error)	36	0.110	0.003	
N				
Between treatments	3	3.329	1.110	8.136
Within treatments (error)	36	4.910	0.136	
P				
Between treatments	3	0.002	0.001	0.454
Within treatments (error)	36	0.045	0.001	
BELOWGROUND BIOMASS				
White Spruce				
Between treatments	3	0.226	0.075	1.390
Within treatments (error)	20	1.086	0.054	
Alfalfa				
Between treatments				
Within treatments (error)				
Wheat				
Between treatments	3	0.007	0.002	2.554
Within treatments (error)	20	0.019	0.001	
Canola				
Between treatments	3	0.051	0.017	3.509
Within treatments (error)	20	0.097	0.005	

Appendix H.2 Analysis of Variance for the Soil Chemistry Data.

Source of Variation	df	SS	Mean Square	F
WATER SOLUBLE IONS				
$\underline{Ca}^{++}$				
Between treatments	3	18418.833	6139.611	160.933
Within treatments (error)	20	763.000	38.150	
$\underline{Mg}^{++}$				
Between treatments	3	2247.667	749.222	120.518
Within treatments (error)	20	124.333	6.217	
$\underline{K}^{+}$				
Between treatments	3	74.458	24.819	37.700
Within treatments (error)	20	13.167	0.658	
$\underline{Na}^{+}$				
Between treatments	3	14.333	4.778	1.412
Within treatments (error)	20	67.667	3.383	
$\underline{SO_4}^{--}$				
Between treatments	3	102614.228	34204.743	46.312
Within treatments (error)	20	14771.342	738.567	
$\underline{Cl}^{-}$				
Between treatments	3	40.125	13.375	0.783
Within treatments (error)	20	341.833	17.092	
NH_4OAc EXCHANGEABLE CATIONS				
$\underline{Ca}$				
Between treatments	3	65536.000	21845.333	3.333
Within treatments (error)	20	131072.000	6553.600	
$\underline{Mg}$				
Between treatments	3	1020.125	340.042	2.464
Within treatments (error)	20	2759.833	137.992	
$\underline{Na}$				
Between treatments	3	88.458	29.486	1.039
Within treatments (error)	20	567.500	28.375	

Appendix H.2 (Continued)

Source of Variation	df	SS	Mean Square	F
K				
Between treatments	3	315.125	105.042	2.798
Within treatments (error)	20	750.833	37.542	
AVAILABLE NUTRIENTS				
NO_3-N				
Between treatments	3	82.792	27.597	13.038
Within treatments (error)	20	42.333	2.117	
P				
Between treatments	3	0.750	0.250	1.538
Within treatments (error)	20	3.250	0.162	
K				
Between treatments	3	578.125	192.708	2.146
Within treatments	20	1795.833	89.792	
SO_4-S				
Between treatments	3	193.281	64.427	34.399
Within treatments (error)	20	37.458	1.873	
OTHER PARAMETERS				
pH				
Between treatments	3	1.135	0.378	151.333
Within treatments (error)	20	0.050	0.002	
Conductivity				
Between treatments	3	1.293	0.431	215.556
Within treatments (error)	20	0.040	0.002	

Appendix H.3 Analysis of Variance for the Soil Leachate Chemistry Data.

Source of Variation	df	SS	Mean Square	F
pH				
Date	2	0.969	0.484	2.998
Treatment	3	1.508	0.503	3.112
Date*Treatment	6	0.431	0.072	0.445
Error	60	9.695	0.162	
CONDUCTIVITY				
Date	2	0.029	0.015	0.450
Treatment	3	1.415	0.472	14.606
Date*Treatment	6	0.268	0.045	1.381
Error	60	1.938	0.032	
IONS				
Ca				
Date	2	1.834	0.917	6.368
Treatment	3	56.234	18.745	130.146
Date*Treatment	6	3.097	0.516	3.583
Error	60	8.642	0.144	
Mg				
Date	2	0.216	0.108	2.397
Treatment	3	18.435	6.145	136.470
Date*Treatment	6	0.906	0.151	3.355
Error	60	2.702	0.045	
K				
Date	2	0.168	0.084	73.608
Treatment	3	0.041	0.014	12.133
Date*Treatment	6	0.022	0.004	3.261
Error	60	0.068	0.001	
Na				
Date	2	0.087	0.044	18.210
Treatment	3	0.019	0.006	2.719
Date*Treatment	6	0.010	0.002	0.678
Error	60	0.143	0.002	

Appendix H.3 (Continued)

Source of Variation	df	SS	Mean Square	F
Cl				
Date	2	0.157	0.079	11.243
Treatment	3	0.028	0.009	1.351
Date*Treatment	6	0.029	0.005	0.693
Error	60	0.420	0.007	
SO_4				
Date	2	3.912	1.956	92.287
Treatment	3	77.275	25.758	1215.332
Date*Treatment	6	4.291	0.715	33.746
Error	60	1.272	0.021	
TOTAL CATIONS				
Date	2	2.902	1.451	3.681
Treatment	3	147.542	49.181	124.780
Date*Treatment	6	7.135	1.189	3.017
Error	60	23.648	0.394	
TOTAL ANIONS				
Date	2	2.712	1.356	43.585
Treatment	3	75.140	25.047	805.071
Date*Treatment	6	4.426	0.738	23.710
Error	60	1.867	0.031	